Newport Research Facility

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Report for the year ended 31st December 2020

This report follows in sequence from the
Annual Reports of the Salmon Research Agency of Ireland Inc.
and the Salmon Research Trust of Ireland Inc.

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Summary

1. The Salmon Research Agency of Ireland merged with the Marine Institute on the 1st July 1999 and in 2010 the group merged with Fisheries Ecosystem Advisory Services. This report provides a continuation of the data records for the Burrishoole facilities in Newport.

2. The total rainfall recorded in Furnace in 2020 was 2033.2 mm. This was the highest annual total recorded since 1977. Of note was the low amount of rain in April and May and the high rainfall in February, June and July. The Met Eireann synoptic station in Furnace also recorded the highest annual rainfall in Ireland in 2020 (2051.7mm) and the hottest day on the 1st June 2020 (27.1°C). Of note in the national statistics were the wet months of February, June, July and August.

3. The environmental programme was maintained in the catchment with the network of rain gauges, water level recorders and river and lake monitoring stations all in operation, apart the Feeagh AWQMS which ceased operation in November 2019, and was refitted throughout 2020. Regular downloads of remote equipment, routine maintenance and replacement of broken equipment, were carried out at all sites.

4. In the last two decades, the physical, chemical and meteorological data have been supplemented with biological datasets describing zooplankton and phytoplankton assemblages in Lough Feeagh and Lough Furnace, along with macroinvertebrate species occurrence and abundance from 16 index sites. It appears that in Lough Furnace, hypolimnetic temperature is warming over the time period 2008-2020, a pattern which warrants further investigation.

5. Tagged reared fish were released into Lough Furnace on April 25th and May 7th. Four tag groups (19,070) were released on April 25th. The release of fish on April 25th was unplanned and was carried out due to rising water temperatures and low dissolved oxygen levels in the tanks putting the fish under stress. In the preceding days the water level in the Mill Race channel that supplies water to the ranched smolt tanks was low due to a prolonged period of dry weather. One group (2,991) was retained in the smolt tanks to facilitate an acoustic telemetry project and the fish were released in the morning on May 7th. Mean weights of smolt groups released into L. Furnace ranged from 63 to 87 gm. Weather conditions at release on April 25th were clear, sunny and calm. At the release on May 7th weather conditions were overcast with a strong north easterly breeze.

6. In 2007, the Irish Government introduced a cessation of drift netting for salmon at sea and this was continued in 2020.

7. A total of 590 wild grilse and 3 previously spawned grilse (psg) were recorded moving upstream through the permanent traps during the season. The number of spring fish recorded was nine. No wild fish were killed in the Furnace rod fishery below the traps.

8. No escaped farm fish were recorded in the upstream traps in 2020.

9. No pink salmon were recorded in 2020.

10. Returning adults were checked for net mark damage; The main migration occurred during July and net marks were recorded on 3.7% (n=270) of the wild fish and 2.6% (n=77) of the ranched fish in July. Rates were also relatively high in June.

Overall the incidence of net marks for the season on wild fish was 3.2% (n=411) and on ranched fish 2.8% (n=106), appreciably higher than in 2019.

11. The maximum spawning escapement was estimated to be 529 wild and 23 reared salmon.

12. A total of 5,996 wild salmon smolts were recorded in the downstream trap in 2020. The wild return of 2019 smolts as wild grilse in 2020 was 10.7%, an improvement on 7.1% in 2019. The ova to smolt survival at 0.54 - 0.48%.

13. Wild kelt survival was 53.8% and the tagged kelt return in 2020 as previously spawned grilse later in the year was 2.1%.

14. The percentage return for reared grilse in 202 from smolts released in 2019 was 6.5%, considerably higher than the 3.3% recorded in 2019.

15. A total of 36 wild sea trout and a further 57 non-silvered trout migrated upstream through the traps in 2020. Of the silvered trout, 14 were adults and 22 (61%) were finnock.

16. The 2020 sea trout smolt run amounted to 92 smolts, the lowest recorded since total trapping began in 1971.

17. The percentage of trout smolts returning as finnock in the same year has historically ranged from 11.4% to 32.4%. In 1989 it collapsed to a minimum of 1.5%. There has been a variable pattern of finnock return in the 1990's between 4 & 10%, rising to 16.7% in 1999. Finnock return in 2020 was 25.3%.

18. Trapping of downstream migrating silver eel continued with the total run amounting to 2122 eels. In 2020, the timing of the run was 11% migrating in August, 9% in September and 69% in October. Almost 90% of the run was completed by the end of October.

19. The Burrishoole rod fishery was closed in 2020 due to COVID-19 Regulations.

20. 2020 marked the completion of 30 years of catchment electrofishing surveys for juvenile salmonids and eel surveys of the lakes for juvenile salmonids. Reduced surveys and no beach seine surveys were carried out in 2020 due to COVID_19 restrictions.

21. Eel fyke net surveys of Feeagh and Furnace were undertaken in 2020 with a reduced effort due to COVID-19. The Furnace survey was carried out in conjunction with GMIT for the EMFF funded Food Web Project.

22. *Anguillicola crassus*, the non-native swim bladder parasite of eel, was recorded in the saline waters of Lough Furnace for the first time in 2011 and each year since. Infection intensity increased year on year but fell in 2016. This is the first known introduction of an aquatic invasive species into Burrishoole. In 2016, 28 silver eels were checked and 10 were found to be infected with adult worms (35.7%) at an intensity of 2.0% - this was the first recorded incidence of *A. crassus* from above the traps in freshwater in Burrishoole. In 2020, the prevalence was 48.1% in Furnace yellow eel and 82.4% in silver eel. There are initial indications that the parasite has spread to Bunaveela and in 2019 an eel PIT tagged in Bunaveela was recorded with 2 worms.

23. In 2020, staff in Newport were authors on 34 peer-review publications and were involved with eleven reports, including nine international science group reports.

Table of Contents

Summary .... **ii**

1 Introduction **1**

2 Environmental Data **2**

2.1 Mill Race Data 2

2.1.1 Rainfall 2

2.1.2 Water Level and Temperature 3

2.2 Catchment Programme 5

2.2.1 Background 5

2.2.2 The 2020 Programme 5

2.2.3 The Black River 5

2.2.4 Lough Feeagh 6

2.2.5 Lough Furnace 9

3 Salmonid Rearing **13**

3.1 Salmon Stocks 2019 13

3.1.1 Ranching 13

3.2 Salmon Stocks 2020 13

3.3 Salmon Stocks 2021 (Grilse ova laid down in 2020/'21) 13

3.4 Experimental Salmon Stocks 2017-2020 14

3.5 Aquaculture Research Salmon Stocks 2019-2020 14

3.6 Aquaculture Salmon Stocks 2020-2021 14

4 Salmon Census Programme **15**

4.1 Wild Salmon and Grilse 15

4.1.1 Wild Salmon & Grilse 15

4.1.2 Fish in MRUT from pool 2020 15

4.1.3 Farm Escapees 15

4.1.4 Pink Salmon 15

4.2 Net marked fish in upstream traps 17

4.3 Wild Spawning Stock 18

4.3.1 Spawning escapement and stock 19

4.3.2 Wild salmon broodstock stripped December 2020 19

4.4 Survival from Ova to Grilse 19

4.5 Ova to Smolt and Smolt to Grilse Survival 21

4.6 Salmon Smolts 22

4.6.1 Wild Salmon Smolts 22

4.6.2 PIT Tag Recaptures 23

4.6.3 Ranched Salmon Smolts 24

4.7 Wild Salmon Kelts 24

4.7.1 Census 24

4.7.2 Tagging of wild kelts 24

5 Reared Salmon Census Programme ... 26
5.1 Coastal Returns ... 26
5.2 Return rate of reared and wild grilse ... 26
5.3 Recapture of Reared 2SW Fish ... 26
5.4 Smolt Releases 2020 ... 26
5.5 Reared kelts ... 27
6 Wild Sea Trout Census Programme ... 28
6.1 Upstream Movements: Timing and Numbers. ... 28
6.2 Tag Recaptures in Upstream Migration ... 29
6.3 Spawning Escapement ... 29
6.4 Downstream Movements, Sea Trout Smolts ... 30
6.5 Tagging and Recaptures in Spring Downstream Migration ... 30
6.6 Autumn Migrating Smolts ... 33
6.7 Tagging and Recaptures in Autumn Downstream Migration ... 33
6.8 Total Recruitment ... 34
6.9 Marine Survival ... 35
6.10 Sea Trout Kelts ... 37
7 Eel Census Programme ... 39
7.1 Silver Eel Numbers ... 39
7.2 Silver Eel Size ... 39
7.3 Elvers ... 42
8 Fishery Report - Catch Data ... 43
9 Catchment Stock Assessment ... 43
9.1 Introduction ... 43
9.2 Electrofishing Surveys ... 43
9.3 Beach Seine Surveys ... 44
9.4 Fyke Net Surveys ... 44
9.4.1 Survey Data ... 44
9.4.2 *Anguillicola crassus* ... 45
9.5 Long-term biological monitoring in the Burrishoole catchment ... 46
10 Collaborative Research Programme ... 55
10.1 GLEON ... 55
10.2 Cullen PhD Fellowships ... 55
10.3 PROGNOS ... 55
10.4 WATExR ... 56
10.5 MANTEL ... 56
10.6 Other catchment ... 56
10.7 DkIT Landscape PhD students ... 56

10.8 BEYOND2020 57
10.9 Unlocking the Archive 57
10.10 Common garden experiments 57
10.11 Pedigree construction 58
10.12 Laboratory studies 58
10.13 Ecological studies - Sticklebacks 59
10.14 AMBER 60
10.15 SALMSON - Super-sized smolt production 60
10.16 HYDRO-fish - Target neutraceutical technologies for a smarter and sustainable Irish aquaculture industry. 61
10.17 SeaMonitor 61

11 Publications 62
11.1 Peer-review 2020 62
11.2 Reports - 2020 65

Annex 1: Upgrade of Smolt Grids on Downstream Traps 66

1 Introduction

This report represents a continuation of the scientific aspects of the Annual Reports published by the Salmon Research Agency of Ireland, now integrated into the Fisheries Ecosystem Advisory Services Group (FEAS) of the Marine Institute. The data presented creates a unique record of fish rearing and wild fish census data for the past 49 years. This data is an essential component in the local, regional and national management of salmon, sea trout and eel and is becoming ever more valuable in the light of increasing pressures on natural stocks, such as exploitation, habitat degradation and global climate change scenarios. The fish monitoring facilities in Newport, along with the reared and ranched salmon stocks held in Burrishoole, are also essential for supporting projects such as development of novel enhancement techniques, alternative stocks and ranching and evaluation of interactions between farmed, ranched and wild strains. An expanding programme in the Burrishoole system is including ecological and genetics research into eel, sticklebacks and stock dynamics of juvenile salmonids and eels.

The new smolt grids installed at the Salmon Leap traps in 2020 (insert: in an October flood).

2 Environmental Data

2.1 Mill Race Data

2.1.1 Rainfall

Daily meteorological data were collected during 2020 at the manual Met Station in Furnace. The monthly rainfall figures for 2016,2017, 2018, 2019 and 2020 are given in Table 2.1, along with the annual totals for the years 1977 to 2020. The total rainfall in 2020 was 2033.2 mm. This was the highest annual total recorded since 1977. Of note was the low amount of rain in April and May and the high rainfall in February, June and July. Daily rainfall amounts are shown in Figure 2.1.

The Met Eireann synoptic station in Furnace also recorded the highest annual rainfall in Ireland in 2020 (2051.7mm) and the hottest day on the 1st June 2020 (27.1°C). Of note in the national statistics were the wet months of February, June, July and August.

Table 2-1: Monthly rainfall totals (mm) for the Furnace Station in 2017, 2018, 2019 and 2020 and the annual totals for 1977 to 2020.

Month	2017	2018	2019	2020	Year	Total	Year	Total
January	87.7	262.7	139.1	127.0	1977	1579.7	2000	1833.2
February	157.7	155.0	107.9	332.2	1978	1592.2	2001	1298.7
March	225.8	87.3	231.2	175.4	1979	1653.3	2002	1715.9
April	25.3	86.2	92.6	23.2	1980	1792.1	2003	1353.2
May	63.1	63.7	110.5	46.3	1981	1646.8	2004	1641.3
June	98.8	61.4	74.2	165.8	1982	1609.6	2005	1608.2
July	181.7	55.4	77.5	184.2	1983	1495.9	2006	1550.7
August	186.3	174.9	243.6	139.3	1984	1556.6	2007	1576.8
September	146.8	142.2	166.3	157.7	1985	1584.1	2008	1805.0
October	169.6	131.2	152.0	238.4	1986	1886.9	2009	1793.9
November	207.0	150.2	142.5	215.5	1987	1373.6	2010	1311.6
December	181.3	189.1	217.3	228.2	1988	1715.2	2011	1826.9
					1989	1583.9	2012	1676.4
Total	1731.0	1559.2	1754.7	2033.2	1990	1805.9	2013	1391.8
					1991	1549.6	2014	1723.1
					1992	1771.1	2015	2011.8
					1993	1473.4	2016	1514.5
					1994	1757.1	2017	1731.0
					1995	1382.5	2018	1559.2
					1996	1286.6	2019	1754.7
					1997	1351.6	2020	2033.2
					1998	1830.9		
					1999	1949.1		

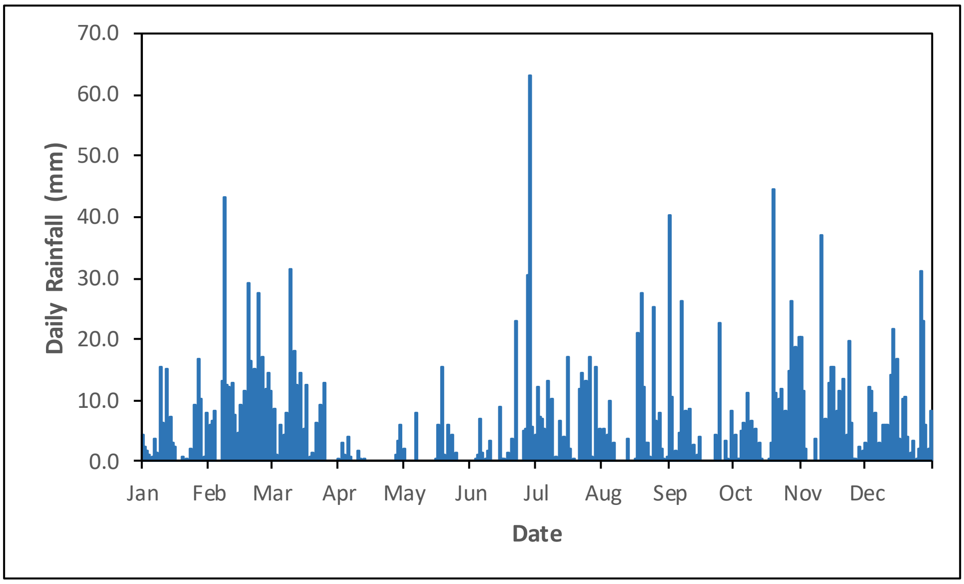

Figure 2-1: Daily rainfall amounts (mm) recorded in the Mill Race manual weather station in 2020.

2.1.2 Water Level and Temperature

Water Level: There is a long term continuous measurement of water level on the Millrace, measured until 2003 with a paper chart recorder, and since then with an OTT Orphimedes water level recorder. Water level for 2019 is presented here. Water levels are recorded every 15 minutes and are presented in Figure 2.2 recorded at 00:00 hrs.

The plot in Figure 2.2 shows a period of relatively low water from April through to late June. A large flood occurred on the 29th/30th June. The remainder of the year was generally wet with no periods of drought.

Water Temperature: There is a long term continuous measurement of water temperature on the Millrace, measured until 2005 with a paper chart recorder. In 2004, a TidbiT temperature logger was installed along with the chart recorder and this records water temperature every 30 minutes. In 2009, this was upgraded to an OTT Orpheus mini sensor and logger. The temperature logger data are presented in Figure 2.3, recorded at midnight. The water temperature data are available at http://data.marine.ie/geonetwork/srv/eng/catalog.search#/metadata/ie.marine.data:dataset.2796

In 2020, water temperatures (recorded at midnight) fell to a minimum of 5.3°C in early March (low temperatures from 18th Feb to 7th Mar), relatively late in the winter. Temperature rose to a peak of 17.6°C on the 2nd June and another warm period from the 9th August to the 20th August with a maximum temperature of 18.9°C on the 12th August. Temperature then fell gradually from the 20th August until the end of the year.

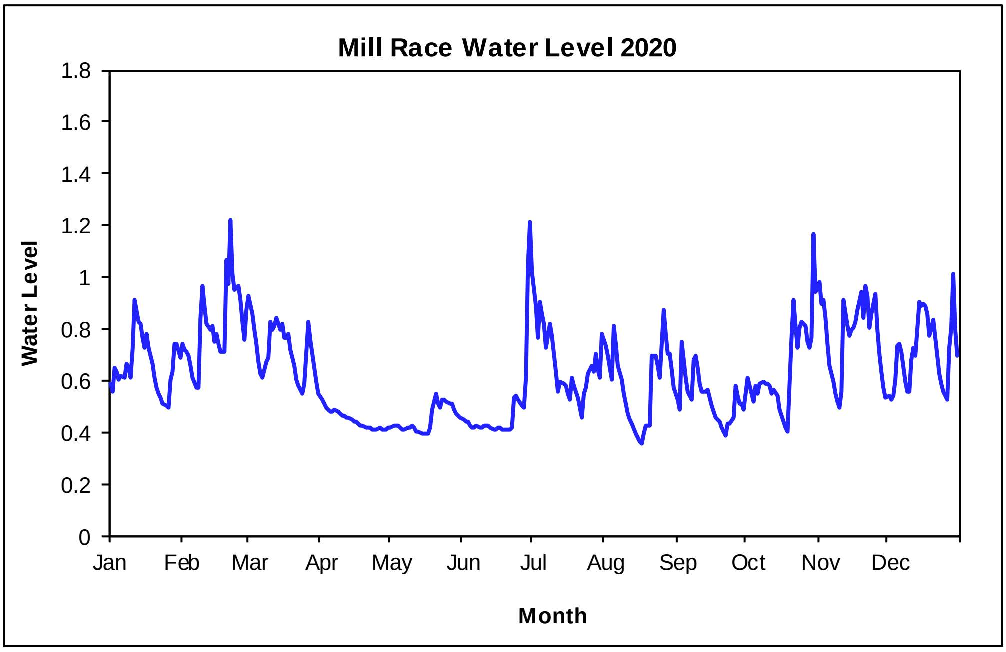

Figure 2-2: Water levels recorded at mid-night for the Mill Race using an OTT Orphimedes automatic water level recorder, 2020.

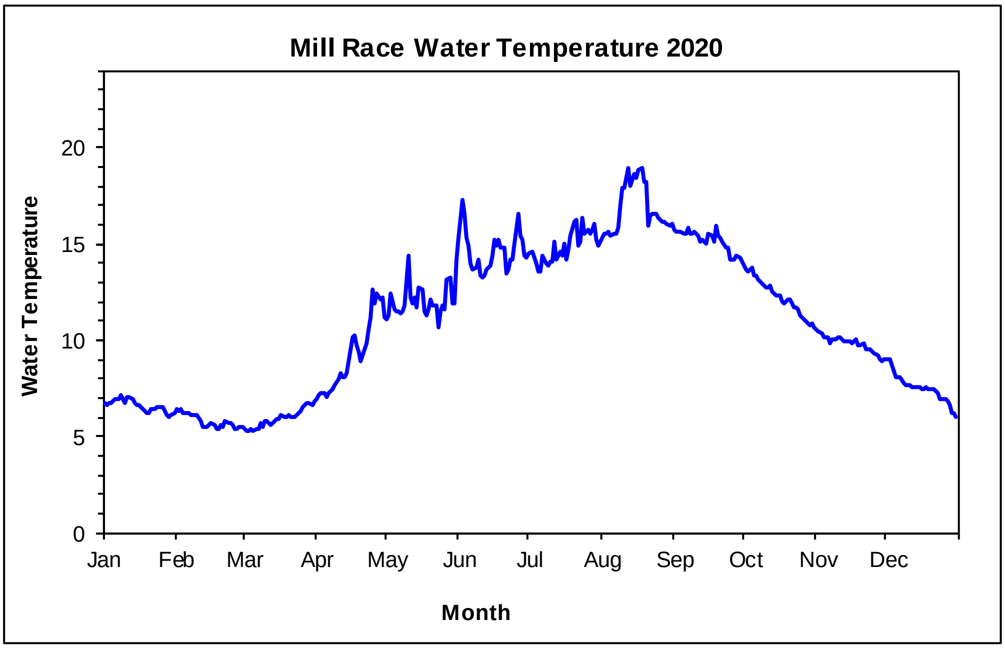

Figure 2-3: Water temperatures (°C) recorded, by OTT Orpheus mini sensor and logger, at mid-night for the Mill Race, 2020.

2.2 Catchment Programme

2.2.1 Background

Over the last thirty years, the Marine Institute has developed a monitoring programme in the Burrishoole catchment, with the aim of ensuring a long term ecological record against which changes in fish biology can be assessed. At the centre of the monitoring program are a series of automatic monitoring stations which measure key aquatic parameters at high frequency. These automatic stations include two lake stations (AWQMS), which have various meteorological instruments included with a suite of underwater temperature and water chemistry sensors, and four river stations, (ARMS), which are equipped with sensors for measuring water temperature, water level, pH, conductivity, dissolved oxygen, and turbidity. The automatic monitoring stations are also equipped with telemetry systems for relaying high-resolution data back to the laboratory. The data from the lake and river stations are complemented by spot samples analysed for water colour, turbidity, Total Phosphorus, Total Nitrogen and ethanol extracted chlorophyll *a*. In addition, the Institute maintains temperature loggers, water level recorders and data-logging rain gauges in the Burrishoole, Owengarve and Owenduff catchments. These instruments allow high-resolution patterns of rainfall to be linked with stream flow. An important feature of the monitoring network is the ability to collect simultaneous data from river, lake, and climatic instruments.

The physical, chemical and meteorological data have been supplemented with biological datasets describing zooplankton and phytoplankton assemblages in Lough Feeagh (since 2003) and Lough Furnace (since 2009), along with macroinvertebrate species occurrence and abundance from 16 index sites (since 2003).

2.2.2 The 2020 Programme

The maintenance and development of long term physical, chemical and biological datasets characterising the freshwater component of the Burrishoole catchment continued in 2020. Regular downloads of remote equipment, as well as routine maintenance and replacement of broken equipment, were carried out at all sites.

2.2.3 The Black River

The main river flowing into Lough Feeagh is the Black River, also known as the Shramore River. A water level recorder is situated approximately 500m above the lake. Figure 2.4 shows the average daily water level for 2020 and Figure 2.5 shows the average monthly water levels from 2002 to 2020.

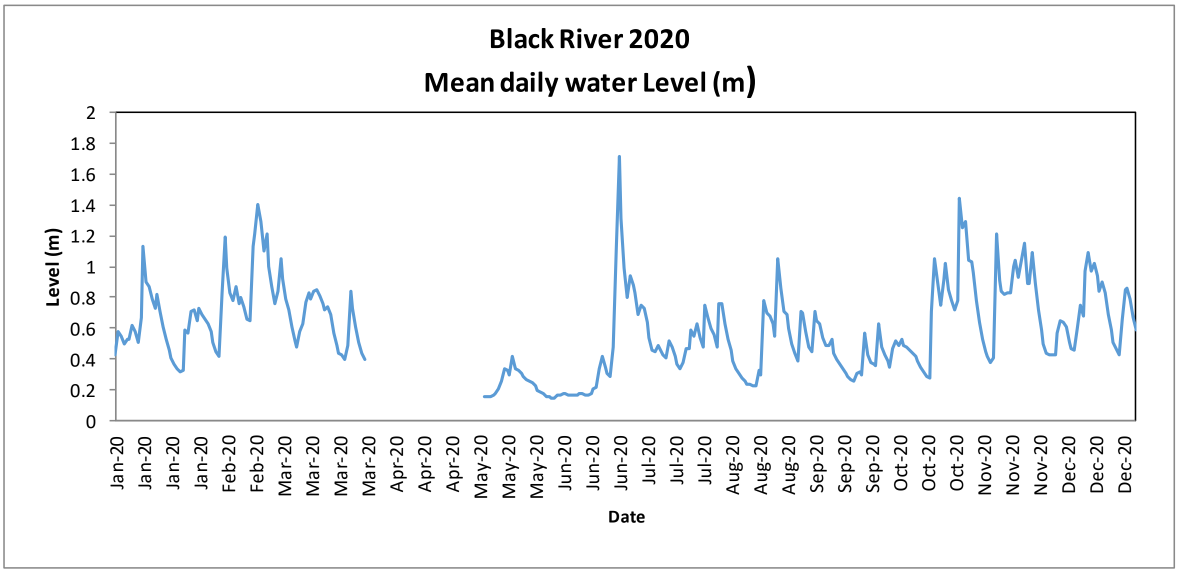

Figure 2-4: Mean daily water level for the Black River, 2020.

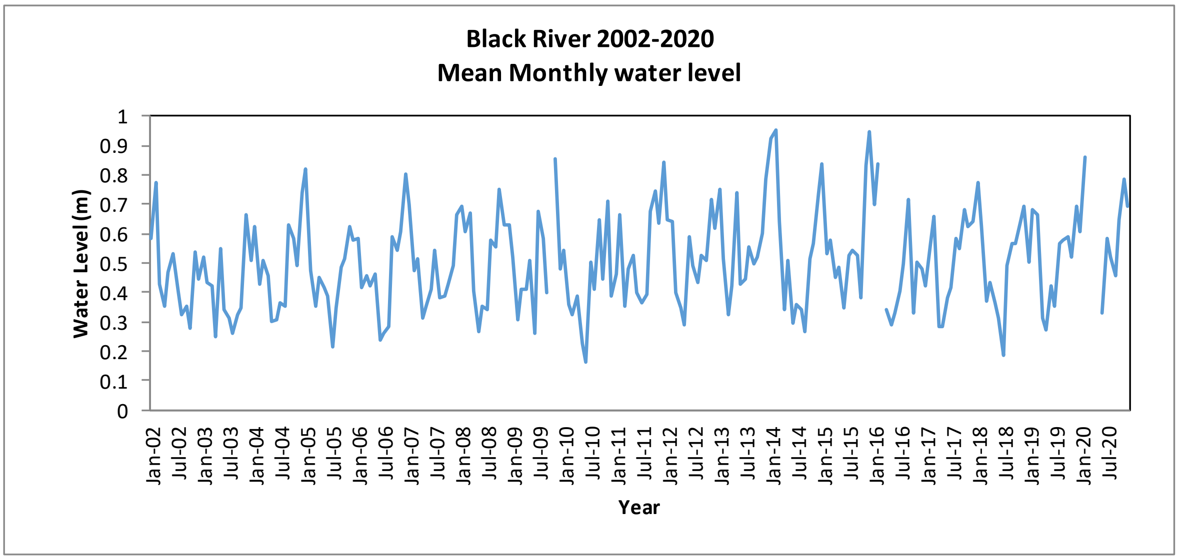

Figure 2-5: Monthly mean water levels for the Black River, 2002-2020.

2.2.4 Lough Feeagh

Lough Feeagh is situated in the Burrishoole catchment in the west of Ireland close to the Atlantic coast and is therefore strongly affected by the temperate oceanic climate that predominates in the region. The water is soft and highly coloured (2020 mean of 73 mgl^{-1} PtCo, n = 11), and is oligotrophic, with Chlorophyll *a* ranging between 0.06 and 2.02 $\mu g\ l^{-1}$ (2020, n=11). Mean annual Total Phosphorous is 6 $\mu g\ l^{-1}$ (2020, n = 11) and Total Nitrogen is 0.46 mgl^{-1} (2020, n = 11). The Lough Feeagh Automatic Water Quality Monitoring System (AWQMS) measures various parameters using a Hydrolab Datasonde 5, two Chelsea Scientific Minitrackas and a Seapoint fluorometer (pH, dissolved oxygen, temperature and conductivity, turbidity, Chl and CDOM fluorescence). There is also a thermistor chain and various weather instruments continually monitoring variables such as barometric pressure, wind speed and wind direction.

Unfortunately, the Lough Feeagh AWQMS ceased operation in November 2019. At this time, the circuit board controlling the logging equipment failed, after almost twenty years of operation. During 2020, the AWQMS was refitted. As a surrogate for the AWQMS data, the 1-D lake model GOTM was run for 2020, using scripts and set ups developed by Tadhg Moore (PROGNOS project) and Seán Kelly (BEYOND2020 project). In summary, GOTM was run through R, with discharge and cloud cover modules turned off. Driving meteorological data was obtained from the Furnace automatic weather station, and lake water level was obtained from http://www.epa.ie/hydronet/#32070. The observed water temperature profiles recorded in October 2019 were used as the boundary conditions for the start of the modelling run. The resulting modelled water temperature was checked against the surface water temperature of the mill race and found to be a relatively good fit. The temperature profile indicates a period of stratification between June and October (Fig. 2.6). Maximum summer temperatures reached 19 °C. (Fig. 2.6). Temperatures were similar to those recorded in the summer of 2019 (Fig. 2.7). The long period of cool hypolimnetic temperatures in early 2020 is probably an artefact of GOTM and should be treated with caution. Nevertheless, the epilimnetic temperatures are considered reliable, and the model indicated a relatively long period of stratification for Feeagh in 2020, in excess of any other year where we have observed data. (Fig. 2.8).

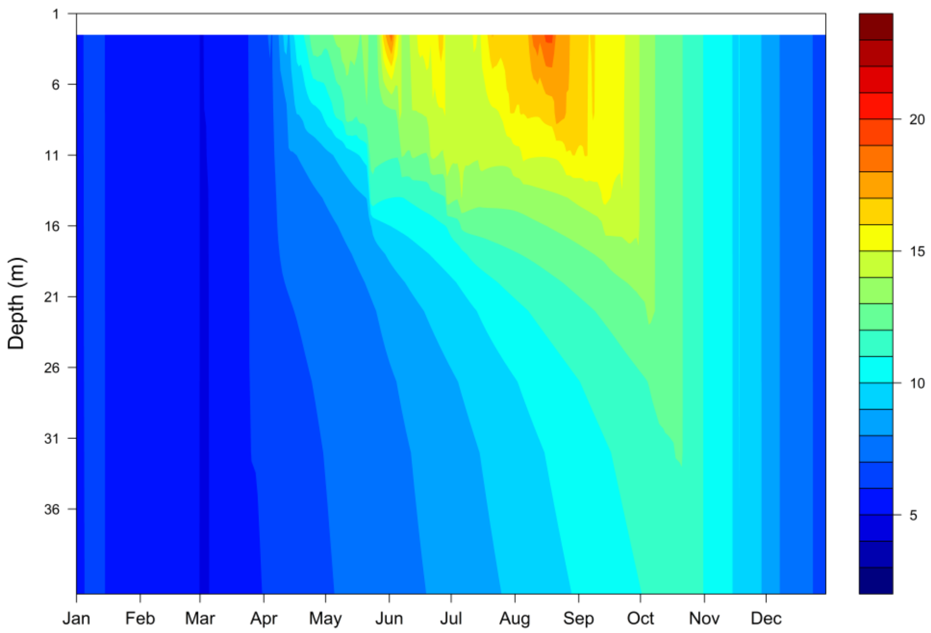

Figure 2-6: Temperature profile for L. Feeagh estimated using the hydrodynamic 1_D lake model GOTM. See text for details.

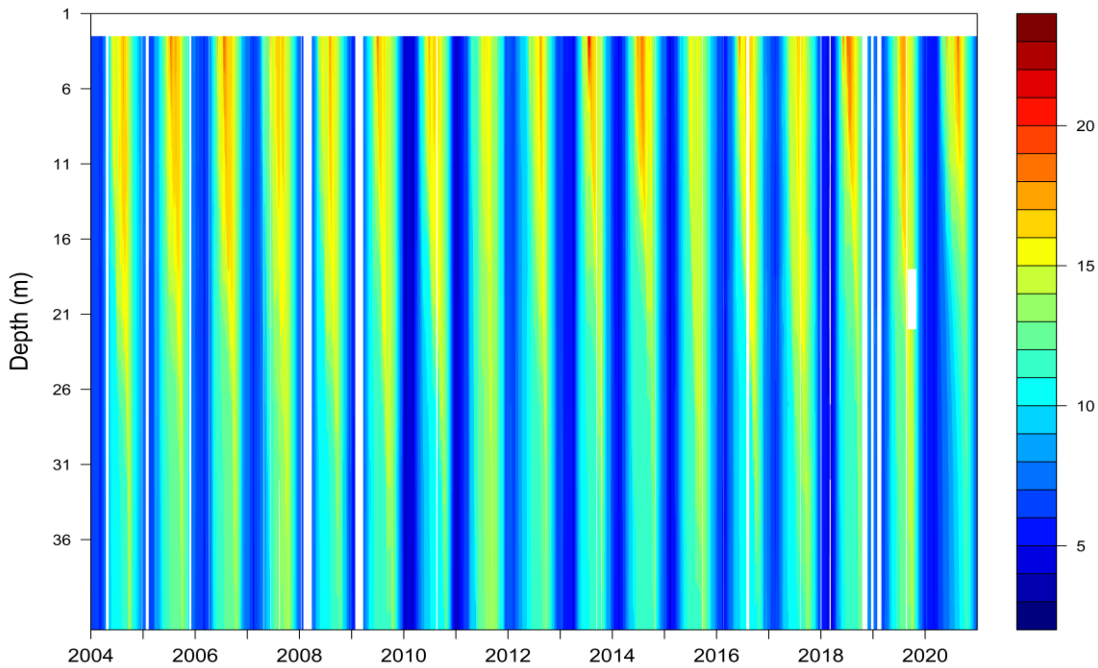

Figure 2-7: Temperature profiles for L. Feeagh measured using PRT sensors on the AWQMS for 2004-2019, and using modelled lake water temperature in 2020. The white areas denote missing data.

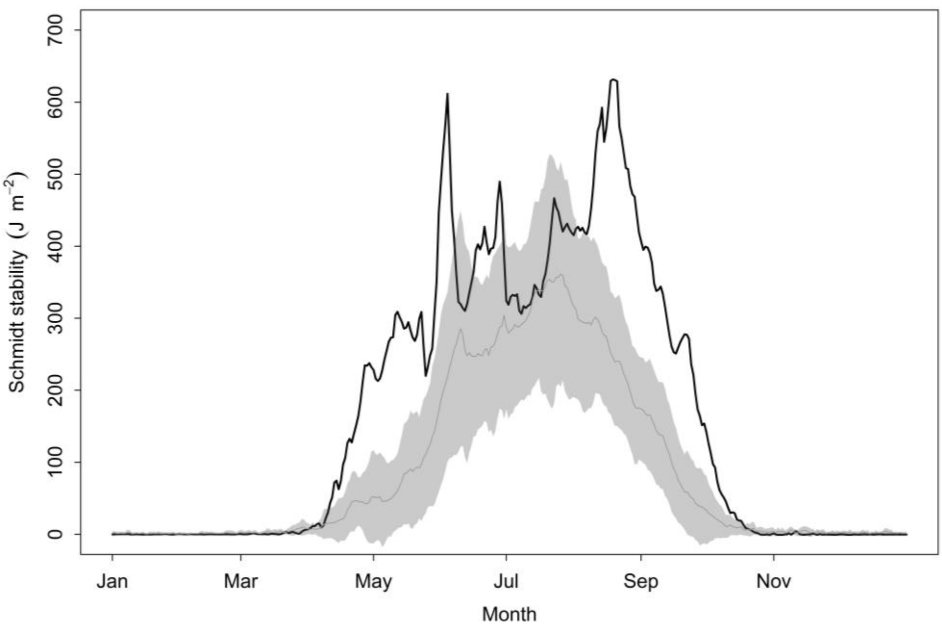

Figure 2-8: Schmidt stability of the water column on Lough Feeagh. The black line indicates the daily measured values for 2020. The grey line indicates the average daily values for the period 2004-2019 ± the standard deviation (shaded grey area).

2.2.5 Lough Furnace

Lough Furnace is situated in the lower end of the Burrishoole catchment. Lough Furnace, (2km from north to south at its widest point, covering an area of 170ha, max depth is 21m with an average depth of 7m) is a cryptodepression tidal lagoon lake. Sea water enters the lake during spring tides but the freshwater exchange ensures relativity low salinities at the surface throughout the year. The lough is thermally stratified throughout the year with spring and autumn inversions and accompanying halo- and oxyclines. Surface Chlorophyll *a* ranged between 0.1 and 17.7μg l^{-1} (2020 Mean annual = 1.74 μg l^{-1}, n=12). Mean annual Total Phosphorous of surface waters was 7.8 μg l^{-1} (2020, n=12) and Total Nitrogen was 0.41 mgl^{-1} (2020, n=12). Monitoring of L. Furnace commenced in the early 1970s and automatic daily monitoring commenced in May 2008. The AWQMS (Fig. 2.9) has a Datasonde DX5 attached to a profiling winch, enabling temperature, conductivity, dissolved oxygen (% and mg/l), salinity, chlorophyll fluorescence and pH profiles of the lake to be taken. The winch profiles the lake 4 times a day (6am, noon, 6pm and midnight), taking four hours to run a profile and is parked for two hours. There is also a nephelometer and fluorometer positioned one meter below the water column. All parameters are measured every two minutes. A weather station is also fully functional on the AWQMS measuring wind direction, wind speed, radiation, relative humidity and barometric pressure.

The AWQMS worked well in 2020, apart from short periods where telemetry connections failed. As with previous years, the water column of Lough Furnace was thermally stratified for 2020, with two very short periods of isothermal conditions in May and October (Fig. 2.10). The hypolimnion was hypoxic below the halocline, and on two occasions (coinciding with the isothermal periods), epilimnetic oxygen levels were low (Fig. 2.11). The epilimnion became very shallow during these occasions with saline water extending almost to the surface (Fig. 2.12). The profiling sonde captured three periods of significant phytoplankton activity, including a deep chlorophyll maximum in spring and early summer, and then an epilimnetic "bloom" at the start of October (Fig. 2.13). Data from the string of HOBO temperature tidbits are also presented here to get a complete picture of stratification over the time period 2008-2020. It appears that hypolimnetic temperature is warming over this time period, a pattern which warrants further investigation. (Fig. 2.14).

Figure 2-9: The Automatic Water Quality Monitoring Station (AWQMS) on L. Furnace (left) and the meteorological instruments attached (right).

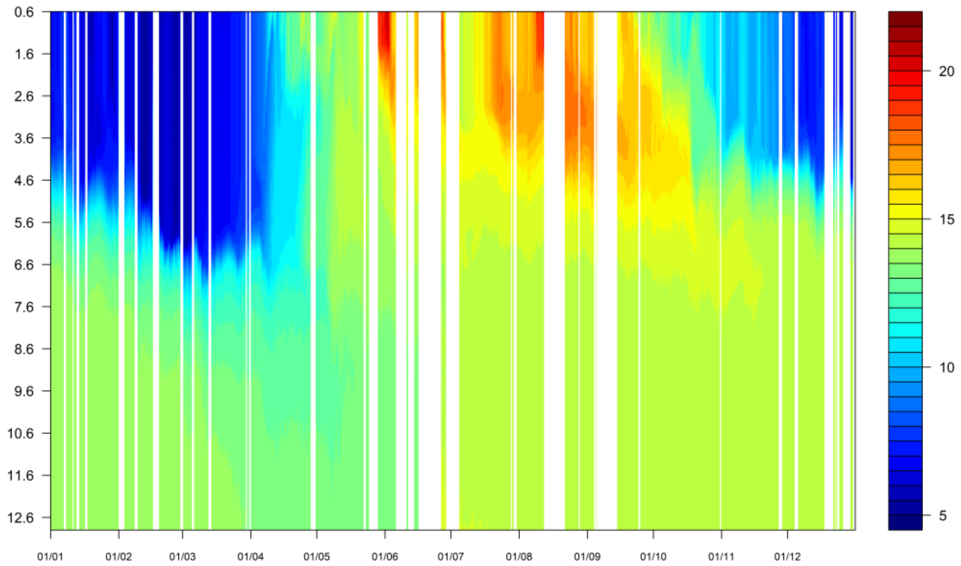

Figure 2-10: Daily average water temperatures (°C) measured every metre at the deepest point in Lough Furnace in 2020. White indicates missing data.

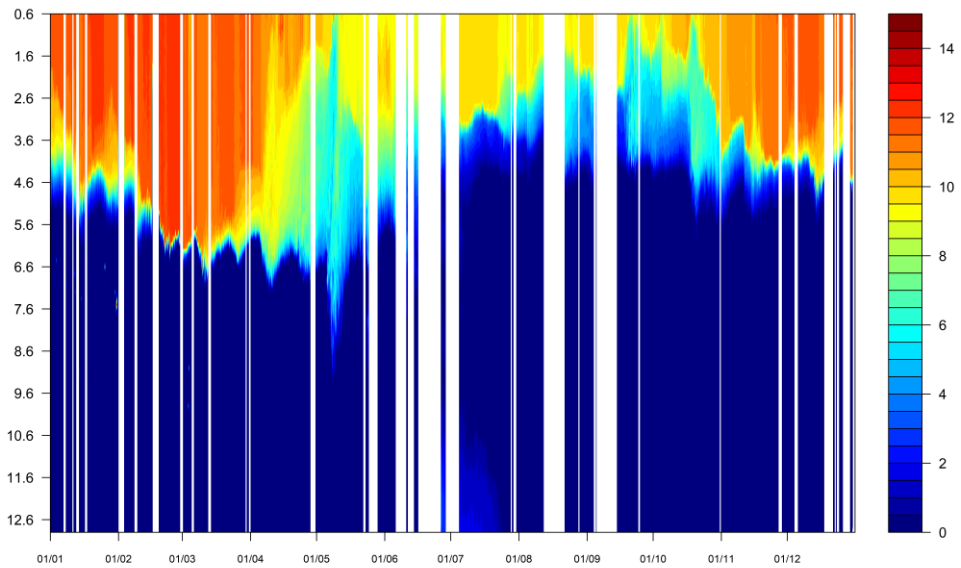

Figure 2-11: Daily average dissolved oxygen (mg/l) measured every metre at the deepest point in Lough Furnace in 2020. White indicates missing data.

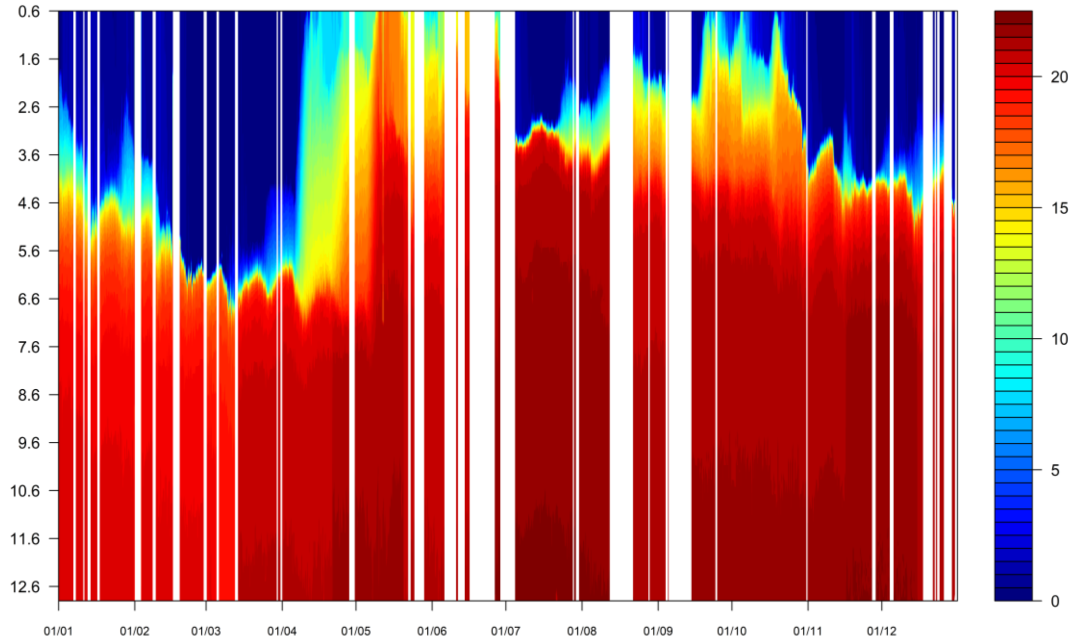

Figure 2-12: Daily average salinity (ppt) measured every metre at the deepest point in Lough Furnace in 2020. White indicates missing data.

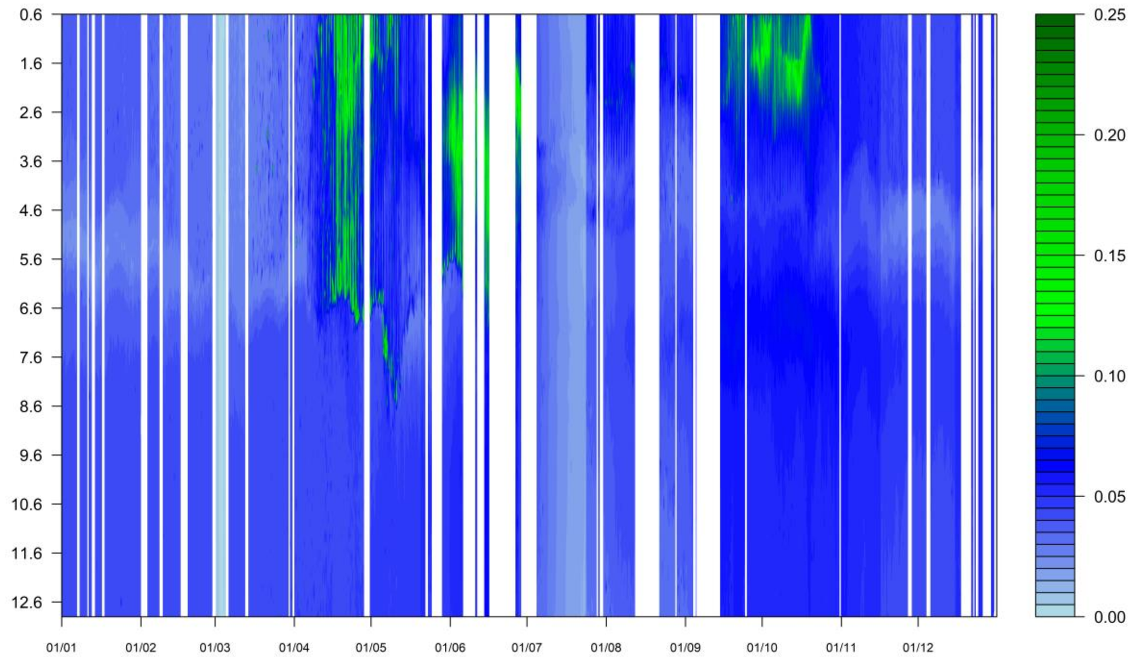

Figure 2-13: Daily average chlorophyll fluorescence (RFU) measured every metre at the deepest point in Lough Furnace in 2020. White indicates missing data.

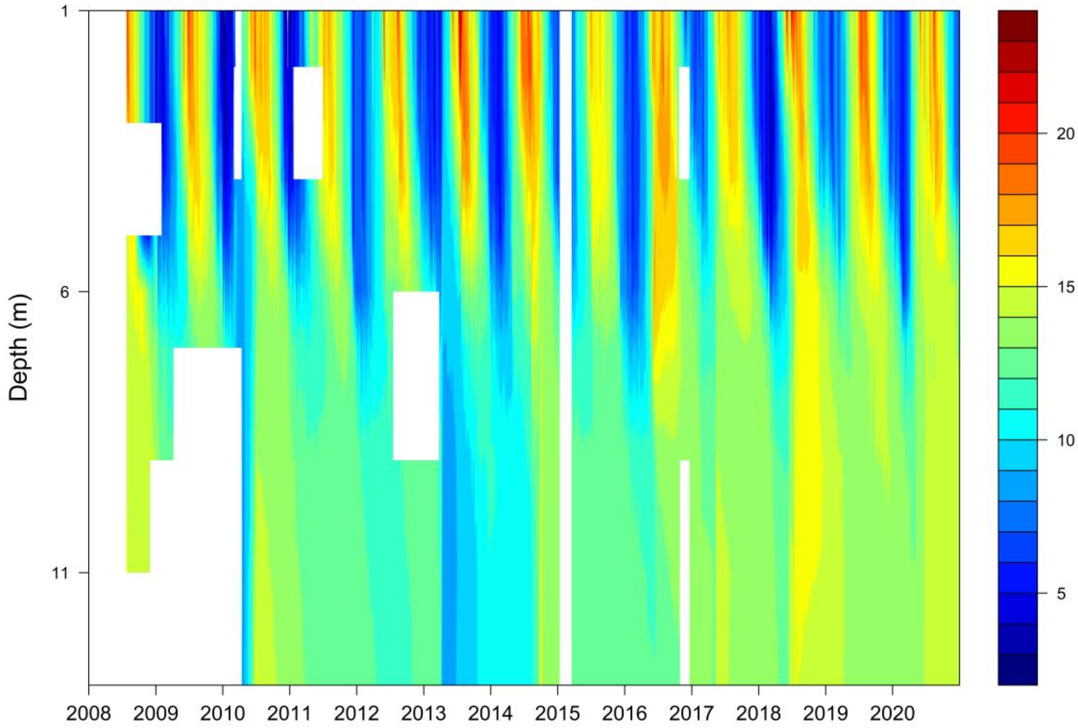

Figure 2-14: Daily average water temperature, Lough Furnace 2008-2020. Data are from the string of Hobo temperature tidbits suspended close to the AWQMS.

3 Salmonid Rearing

3.1 Salmon Stocks 2019

3.1.1 Ranching

The total release in 2020 of microtagged smolts of ranched Burrishoole grilse origin was 22,061 comprising 5 tag codes. Fish were released into Lough Furnace on April 25th and May 7th. Four tag groups (19,070) were released on April 25th. The release of fish on April 25th was unplanned and was carried out because rising water temperatures and low dissolved oxygen levels in the tanks was putting the fish under stress. In the preceding days the water level in the Mill Race channel that supplies water to the ranched smolt tanks was low due to a prolonged period of dry weather. One group (2,991) was retained in the smolt tanks to facilitate an acoustic telemetry project (SeaMonitor, section 10.17) and the fish were released in the morning on May 7th. Mean weights of smolt groups released into L. Furnace ranged from 63 to 87gm. Weather conditions at release on April 25th were clear, sunny and calm. At the release on May 7th weather conditions were overcast with a strong north easterly breeze.

Tag code details are shown in Table 5.1.

3.2 Salmon Stocks 2020

An estimated 50,000 Burrishoole ranch eyed ova from five stripping dates were retained for on-growing. Water temperatures ranged from 6.8°C at the commencement of first feeding on April 1st to 11.2°C on May 6th when the last group commenced first feeding. Growth and survival were good with an overall survival of 89% from first feeding to grading in August. Ranch salmon were mixed after grading in August to produce core medium and large grade release groups. Stock remaining in December 2020 was 29,175.

3.3 Salmon Stocks 2021 (Grilse ova laid down in 2020/'21)

Broodstock collection commenced on August 21st 2020 and salmon were transferred from the traps directly to the broodstock holding pond. Broodstock collection continued into December and in total 605 ranch adults (311 females, 294 males) were held during the stripping period (December 2020). A total 199 females and 208 males were stripped (total 407). Microtags were read following stripping and broodstock from the 2019 UCC/SFI experimental groups were identified including Fanad and reciprocal hybrid fish. Only families derived from crossing pure SRA broodstock were retained for the ranching programme. There were 5 families derived from crossing SRA broodstock with broodstock of unknown origin (no microtag found) and these were euthanized. Families (n=20) derived from crossing UCC/SFI and SRA broodstock were transferred to separate flumes after the eyed ova stage and were allowed to develop until they reached swim up fry stage. They were routinely sampled for the UCC/SFI research programme throughout these development stages and all remaining fry were euthanized. This left a total of 174 pure SRA families for hatching. Remaining surplus fish were culled on 9th January 2021.

In December, average water temperature was 7.0°C, ranging 5.5°C to 8.6°C. Salmon were examined weekly, over a four-week period (December 3rd to 22nd 2020) to recover ripe females for egg production. Broodstock condition was good throughout the holding period, although formalin treatments were necessary during October and November. Thirty ranch salmon broodstock were sampled in January 2021 and subsequently certified by the Marine Institute Fish Health Unit as disease free.

An estimated 683,367 green ova were produced by 174 females. The average fecundity value was 3,840 ova per grilse female (n=73) and 8,909 ova per 2SW female (n=1). A proportion of each family, from confirmed Burrishoole stock, was retained in the hatchery from each of the four stripping dates, totalling 47,704 eyed ova from 174 females and 183 males. Ova quality and survival was good.

3.4 Experimental Salmon Stocks 2017-2020

The Institute are collaborators with UCC in a research programme funded by Science Foundation Ireland (SFI), 'Wild farmed interactions in a changing world: formulation of a predictive methodology to inform environmental best practice to secure long-term sustainability of global wild and farm fish populations'. Previous experiments undertaken as part of this research programme are described in the 2019 annual report. In May 2019 three groups of smolts, two reciprocal crosses (n=5,234) and one pure Fanad group (n=2,604) were fin clipped, freeze branded (O, T, X, H), coded wire tagged and released to Lough Furnace. Information on the return rates of these groups is provided in Marine Institute 'National Report for Ireland - The 2020 Salmon Season' report. In December 2020 broodstock from these groups were stripped and further information is given in section 3.3.

3.5 Aquaculture Research Salmon Stocks 2019-2020

The Institute are collaborating on two aquaculture research programmes that utilise the Newport research and fish rearing facilities. Further information on these programmes is outlined in sections 10.15 and 10.16.

In April and May 2020 S1 smolts of Mowi (7,827) and StofnFiskur (5,019) origin that were reared in the flow-through fish rearing facility and were transferred to the Institute's marine site at Lehanagh Pool, Co. Galway for on-growing as part of the HYDROfish trial.

3.6 Aquaculture Salmon Stocks 2020-2021

In January and February 2020 ova were sourced from two hatcheries that produce salmon for the commercial aquaculture sector. 31,158 ova were sourced from StofnFiskur, Iceland along with 32,838 ova from Mowi Ireland, Co. Donegal. All ova were derived from broodstock certified as disease free. These ova were on-grown at the flow-through and recirculating aquaculture system (RAS) fish rearing facility in Newport. In October, 750 Mowi parr were transferred to the NUIG research station in Carna, Co. Galway for use in the HYDROfish trial. In November 2020, 8,270 S0 smolts were transferred to the Institute's marine site at Lehanagh Pool, Co. Galway, for on-growing. Stock remaining in December 2020 was 32,203 comprising of 12,345 of Mowi origin and 19,858 of StofnFiskur origin.

4 Salmon Census Programme

The salmon census and stock assessment programme was continued in 2020 with a full upstream and downstream census of migrating wild salmon. The data provides a valuable index of salmon survivals (freshwater and marine) and stock dynamics for the freshwater components of the stock.

Note that due to Covid-19 restrictions, sampling protocols were modified during 2020 in accordance with Government recommendations and to maintain collection of essential data time series.

4.1 Wild Salmon and Grilse

4.1.1 Wild Salmon & Grilse

A total of **590** wild grilse were recorded moving upstream through the permanent traps during the season, **3** previously spawned grilse (from floy tag or pit tag returns) were recorded, (Table 4.1 and 4.2).

The total number of spring fish recorded for the year in the upstream traps was **9**.

No wild fish were killed in the Furnace rod fishery below the traps. Therefore, the total wild grilse return to fresh water was **590** and **3** previously spawned grilse.

The water conditions during April, May and early June were generally very low. The first significant rain occurred on the afternoon and evening of June 22nd and the first wild grilse was recorded in the SLUT the following day. The run commenced in the MRUT on June 30.

The peak of the upstream migration occurred between 18 – 20th July and there was a late run of wild grilse recorded in the MRUT during December, see Section 1.1.2 below.

The fish returning in 2020 were in very good condition and although it was not possible to take weights of returning wild grilse, observations would suggest that grilse were heavier than had been observed for several years.

4.1.2 Fish in MRUT from pool 2020

The phenomenon where both ranched and wild salmon hold up in the Mill Race pool during October, November and December was again observed in 2020. As in the previous year despite high water levels during this period, which generally encourage fish to move upstream, a high number of fish were still present in the pool during December when a total of 219 ranched fish and 37 wild fish were recorded in the MRUT during December. There has been a significant increase in the numbers of wild fish recorded during December in recent years. In 2018, two wild fish were recorded in the MRUT during December, this increased to 25 in 2019 and increased again in 2020 to 37.

4.1.3 Farm Escapees

There were no farm escapes recorded in 2020.

4.1.4 Pink Salmon

There were no Pink Salmon (*Oncorhynchus gorbuscha*) recorded in 2020.

Table 4-1: Monthly wild grilse totals for the Salmon Leap and Mill Race traps, 2020.

	Mill Race	Salmon Leap	Total	%
May	0	0	0	0.0
June	1	99	100	16.9
July	26	327	353	59.8
August	0	40	40	6.8
September	0	3	3	0.5
October	39	4	43	7.3
November	5	0	5	0.8
December	43*	3	46	7.8
	114	476	590	100

*Includes 5 wild grilse misidentified and counted as ranched grilse into the broodstock pond in the last 3 months.

Table 4-2: Monthly proportions (%) of the wild grilse run timing 2009-2020.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
May	0.0	0.0	0.2	0.1	0.7	0.4	0.0	0.9	0.6	0.3	0.0	0.0
June	4.6	0.9	16.8	29.8	13.2	11.8	1.9	37.7	40.8	12.6	17.8	16.9
July	78.7	75.8	43.4	57.1	45.0	61.6	86.6	29.1	43.7	5.4	59.8	59.8
August	15.5	15.5	29.8	10.1	26.6	19.2	6.1	9.2	12.7	76.3	11.1	6.8
September	0.9	6.7	8.4	2.4	10.3	0.7	2.5	6.6	0.6	3.2	4.3	0.5
October	0.2	1.0	0.6	0.4	2.6	4.8	0.8	12.5	0.9	0.6	0.9	7.3
November	0.2	0.1	0.8	0.0	1.6	1.1	2.0	3.8	0.8	0.9	0.5	0.8
December	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.2	0.0	0.6	5.6	7.8

Table 4-3: Wild salmon, grilse and previously spawned grilse (PSGs identified from floy tag recoveries) totals in the upstream traps, 1970-2020; 5 year means and annual data from 2000. * years where the grilse count was raised to account for loss in the traps.

Year	Total Salmon	Total Grilse	Previously Spawned Grilse
1970-'74	14	1145	
1975-'79	36	703	
1980-'84	35	449	
1985-'89	22	492	
1990-'94	16	421	
1995-'99	12	509	
2000-'04	12.0	541.6	
2005-'09	22.4	641.6	15.5
2010-'14	26.8	572.2	10.6
2015-'19	13.8	490.8	2.0
2000	6	568	
2001	6	368	
2002	2	648	
2003	18	544	
2004	28	580	
2005	9	532	
2006*	31	530	
2007*	12	1049	
2008	23	548	21
2009	37	549	10
2010	17	686	17
2011	50	523	7
2012	18	671	6
2013	23	710	15
2014	26	271	8
2015	11	635	4
2016	16	530	2
2017	9	529	3
2018	19	317	1
2019	14	443	0
2020	9	590	3

4.2 Net marked fish in upstream traps

In 2007, the Irish Government introduced a cessation on drift netting in Irish coastal waters. The overall incidence of net marks recorded since the cessation in 2007 remains low.

The upstream migration of salmon during 2020 commenced in June and net marks were observed on both wild and ranched fish. The incidence for wild fish in June was 3.1% and 3.6% for ranched fish and in July was 3.7% and 2.6% for ranched fish. These rates were approximately double those recorded in 2019.

The overall incidence of net marks during the season was 3.2% for wild grilse and 2.8% for ranched grilse.

Table 4-4: Percentage occurrence of net marks on wild and reared salmon, 2020.

	Wild Grilse %	n for wild/month	Reared Grilse %	n for reared/month
May	0.0	0	0.0	0
June	3.1	97	3.6	28
July	3.7	270	2.6	77
August	0.0	39	0.0	1
September	0.0	1	0.0	0
October	0.0	1	0.0	0
November	0.0	0	0.0	0
December	0.0	3	0.0	0
Total	3.2	411	2.8	106

4.3 Wild Spawning Stock

The spawning stock (escapement) represents the number of fish available for spawning. It is calculated by subtracting rod caught fish and downstream-displaced fish as well as losses due to poaching, disease and predation, which have been estimated at 5% for wild fish and 10% for reared fish not displaced downstream.

In both 2006 & 2007, an additional number of fish, reared and wild, escaped upstream undetected (see previous reports). It is likely that the wild grilse count for those years were minimum figures and this was taken into account for all calculations based on the 2006 & 2007 spawning escapements.

In 2018, it was noted that more reared grilse were recorded in the downstream traps in the autumn than in the upstream traps in the summer. Many of these fish in the DS traps had no floy tag or tag scar. It is likely that these fish ascended around the Mill Race fish fence in high floods in September and, most likely, in October. The reared fish figures have been amended to account for this. A new fish fence was installed in 2019 along the walkways of the Mill Race pool to try to minimise this problem.

In 2019 a total of 117 ranched fish were released upstream and by December 2019 117 were recorded in the downstream traps. However, an additional 22 ranched fish were recorded in the downstream traps during 2020. It is likely that some ranched fish escaped upstream unrecorded when the fish fence was over-topped in December 2019.

The numbers of ranched kelts recorded during 2021 would suggest that the issue of ranch fish bypassing the MRUT during flood conditions did not occur during 2020.

4.3.1 Spawning escapement and stock

The total spawning stock in 2020 consisted of 529 wild fish and 23 reared fish (Table 4.5).

Table 4.6 gives the annual total spawning escapement, the wild escapement and the reared fish component. The average spawning escapement of wild fish since 2010 is 501 and has varied from 260 to 691. While the wild spawning escapement was lower than the conservation limit (581 grilse or 617 total wild), the fish returning in 2020 were heavier than in recent years and more likely to have a higher fecundity.

4.3.2 Wild salmon broodstock stripped December 2020

No wild fish were taken for broodstock from the catchment in 2020.

Table 4-5: Spawning stock of salmon and grilse, 2020.

	Wild grilse (1SW) & previously spawned grilse	Wild Salmon (2SW)	Ranched fish released upstream
Counted in trap	593	9	158
Rod Feeagh	0	0	0
Culled	5	0	0
Broodstock UT	0	0	0
Broodstock DT	0	0	126
Broodstock Upper Catchment	0	0	0
Estimated morts.	28	1	3
Displacement	39	0	6
Spawning stock	**521**	**8**	**23**

4.4 Survival from Ova to Grilse

The relevant brood year for the 2020 grilse was 2016 with ova hatched in 2017 and smolt migration in 2019 (Table 4.7).

As in previous years, it has been assumed for the purpose of estimating survival that ranched grilse spawned naturally. Specific data are not currently available on differential survival rates of wild and ranched stocks spawned in the wild, although new genetic data may facilitate this analysis in the future. All relevant calculations are based on parameters set out in the Ann. Rep. No. 19, 1974.

Table 4-6: Spawning escapement, 1970-2020.

	Maximum spawning escapement	Wild fish component	Reared fish component
1970-'74	1126	986	140
1975-'79	725	683	42
1980-'84	474	430	44
1985-'89	662	428	232
1990-'94	603	348	254
1995-'99	519	428	95
2000-'04	516	494	21
2005-'09	624	587	38
2010-'14	571	544	27
2005	503	472	31
2006	552	520	32
2007	1038	958	80
2008	512	495	17
2009	517	489	28
2010	652	617	38
2011	548	512	36
2012	668	640	28
2013	702	691	11
2014	284	260	24
2015	601	583	18*
2016	539	492	47
2017	530	478	52
2018	340	289	51*
2019	483	424	59*
2020	552	529	23

* estimated, see table 4.5 in those years.

Table 4-7: Survivals from ova to smolt and smolt to grilse.

Spawning escapement in 2016	539
No. of females*	270-297
Ova deposition	1,078,000 - 1,219,892
No. of smolts in traps 2019	5863
No. of smolts released	5535
Survival ova to smolt	0.54 - 0.48
No. returning grilse 2020	590
Survival smolt to grilse	10.66
Survival to grilse per grilse female	2.17 - 1.97

* two estimates of the % females in the run using 50% and 55%

4.5 Ova to Smolt and Smolt to Grilse Survival

The survival of ova to smolt recorded for the 2019 smolt cohort was 0.54-0.48 from a spawning escapement of 539 adults in 2016 (Table 4.7).

The percentage return of grilse in 2020 from the 2019 smolt output was 10.7%, which is an increase from 7.1% the previous year.

The survival to grilse per grilse female was 1.97 – 2.17 (Tables 4.7- 4.8).

Table 4-8: Percent survivals for ova to smolt and grilse per female grilse spawner; comparative data for 5-year averages from 1970-2009 and values for the individual brood years from 2005 onwards.

Brood year-class	% survival rates ova to smolt	survival rates to grilse per grilse female spawner
1970-'74	0.48 - 0.62	1.4 - 1.7
1975-'79	0.63 - 0.73	1.5 - 1.7
1980-'84	0.61 - 0.69	1.7 - 1.9
1985-'89	0.44 - 0.45	1.4 - 1.5
1990-'94	0.43 - 0.49	1.5 - 1.7
1995-'99	0.63 - 0.70	1.9 - 2.0
2000-'04	0.69 - 0.79	2.3 - 2.6
2005-'09	0.56 - 0.64	2.0 - 2.2
2005	0.61 - 0.69	2.0 - 2.2
2006	0.67 - 0.75	2.4 - 2.6
2007	0.30 - 0.34	0.9 - 1.0
2008	0.57 - 0.65	2.4 - 2.6
2009	0.66 - 0.75	2.5 - 2.7
2010	0.43 - 0.49	0.8 - 0.9
2011	0.66 - 0.74	2.1 - 2.3
2012	0.47 - 0.53	1.4 - 1.6
2013	0.46 - 0.52	1.4 - 1.5
2014	0.78 - 0.89	2.0 - 2.2
2015	0.48 - 0.54	1.3 - 1.5
2016	0.48 - 0.54	2.0 - 2.2

4.6 Salmon Smolts

4.6.1 Wild Salmon Smolts

The main smolt run occurred predominantly in May (91%) with the Mill Race receiving more smolts in early May and then the Salmon Leap later in May (Table 4.9). The total for 2020 was 5,996, similar to that in 2019 (Table 4.10).

Smolt counting and sampling in the downstream traps during 2020 was carried out under Covid 19 guidelines. As a result, fewer staff were available to carry out both the normal smolt sampling and the recovery of pit tagged smolts during the migration. Fortunately, water flow in the downstream traps during much of the migration enabled smolts to migrate continuously in relatively low daily numbers rather than in pulses which can happen following a period of low water and resulting in high daily counts. As a result, it was possible to carry on the smolt sampling programme under Covid 19 restrictions with the minimum of stress on migrating smolts.

The downstream migration commenced in both traps during March with 0.25% of the run recorded. Water levels were low during April and 4.8% of the run was recorded. Water levels were also low during early May and smolts migrated predominantly through the Mill Race (Fig. 4.1). The first significant rain occurred during May 17th. From the 19th May there was a significant increase in smolts at both traps and 91% of the total run was recorded in May (Fig.4.1).

Table 4-9 : Number and proportion of wild salmon smolts counted monthly in 2020.

Month	Salmon Leap Down Trap	Mill Race Down Trap	Total	%
March	7	1	8	0.1
April	150	136	286	4.8
May	3016	2446	5462	91.1
June	95	115	210	3.5
July	26	4	30	0.5
August	0	0	0	0.0
September	0	0	0	0.0
TOTAL	**3296**	**2702**	**5996**	**100**

Table 4-10: Annual numbers of wild salmon smolts recorded in the downstream traps and the number released after sampling and mortalities have been removed.

Year	1990-'94	1995-'99	2000-'04	2005-'09	2010-'14	2015-'19	2015	2016	2017	2018	2019	2020
Smolts Counted	5618	7052	7490	7351	7195	6353	7034	7362	5029	6475	5863	5996
Smolts Released		6967	7340	7138	6966	6136	6832	7170	4918	6227	5535	5896

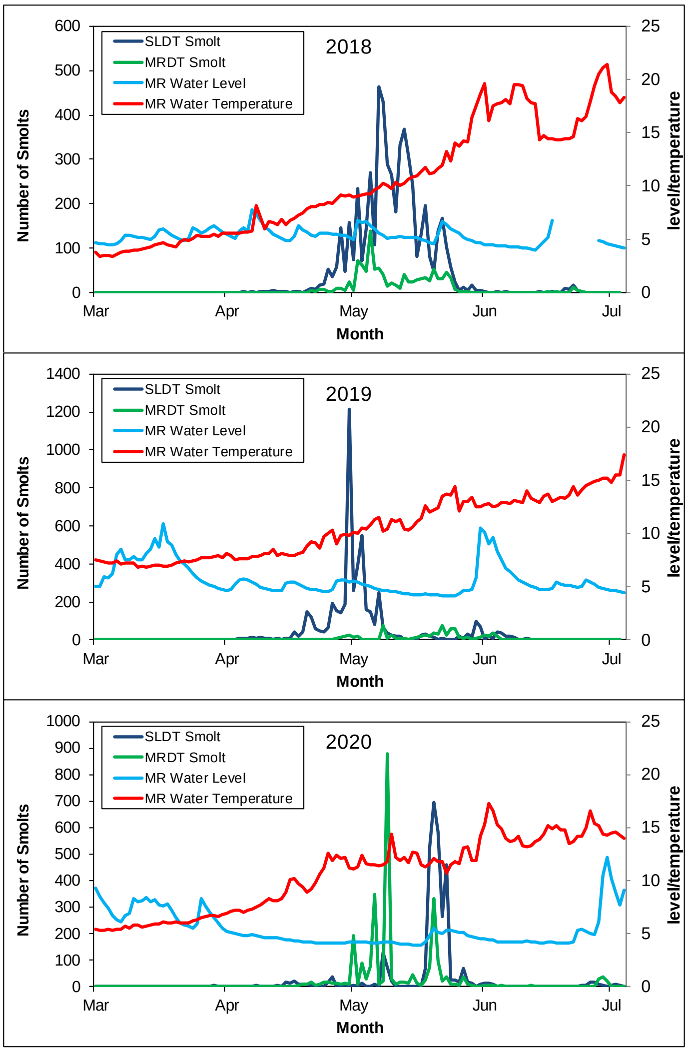

Figure 4-1: Timing of the 2018, 2019 and 2020 wild salmon smolt runs in the Salmon Leap and Mill Race traps with daily midnight MR water level (m x 10) and midnight temperature (^{0}C).

4.6.2 PIT Tag Recaptures

In 2018, 230 wild salmon smolts with PIT tags were recorded in the downstream traps between January and August, of which 224 were released downstream. These fish were previously tagged as parr in the catchment as part of a Cullen Fellowship project. No wild salmon parr with PITs were recorded in the rest of the year.

Of the 224 wild smolts released with tags in 2018, seven were recovered as wild grilse in 2019, a recovery rate of 3.1%.

In 2019, 40 wild salmon smolts (or putative wild with origin unconfirmed) were recorded with PIT tags in the downstream traps, 35 were sampled and five were released on downstream.

In 2020, six wild salmon smolts (or putative wild with origin unconfirmed) with tags were recorded and no wild salmon parr with PITs were recorded in the rest of the year. None of these were released downstream.

4.6.3 Ranched Salmon Smolts

There were no ranch smolts released directly into the catchment above the traps in 2020.

In 2018, 30 PIT tagged salmon smolts of reared origin, released from the Rough River Trap, were recorded in the main downstream traps, of which 22 were released downstream. One was recovered in 2019 as grilse, a recovery rate of 4.5%.

In 2019, 71 PIT tagged experimental smolts from the Rough River were recovered in the downstream traps, of which nine were released on downstream making a total release of 14 smolts (5 wild & 9 RSS) with adipose fins and PIT tags.

In 2020, 178 PIT tagged experimental smolts from the Rough River were recovered in the downstream traps, of which none were released on downstream. Of the 178 smolts, 161 were confirmed as "experimental", 11 as undetermined origin and six as wild Rough River (these six were included in the wild smolt total).

4.7 Wild Salmon Kelts

4.7.1 Census

Kelts migrate downstream after spawning. A total of 228 wild salmon kelts were recorded in the downstream traps between December 2019 and May 2020 (Table 4.11).

Survival of wild fish to kelt was 53.8% and 94.4% of these were recorded as being in good condition (Table 4.12).

Table 4-11: Numbers of wild salmon kelts counted in 2020.

Month	SLDT	MRDT	Total
December '19	11	1	12
January '20	23	2	25
February	66	6	72
March	97	1	98
April	3	12	15
May	3	3	6
June	0	0	0
Total	**203**	**25**	**228**

4.7.2 Tagging of wild kelts

Following the cessation of drift netting during 2007 and the corresponding increase in the wild spawning stock at Burrishoole, annual tagging of the wild kelts recommenced during 2008.

A total of 140 floy tagged kelts were released from the downstream traps in spring 2020. A total of 75 fish also had PIT tags inserted.

Subsequently during the summer of 2020, 3 previously spawned grilse were recorded. The 3 fish were identified by floy tag and one of the floy tagged fish also had a pit tag (Table 4.12).

One fish (2SW) was identified as a fish that was tagged in the Rough river in 2017.

The percentage recovery of PSGs decreased from 1.6% in 2017 to 0.6% in 2018 and 0% in 2019 but was 2.1% in 2020 (Table 4.12).

Table 4-12: Comparison of annual salmon kelt runs. A = % healthy kelts in kelt run, B = % males in kelt run, C = % lightly marked, D = % survival from wild spawning escapement, E = % recapture of previously spawned grilse in first year.

Year	Kelt Quality Grade				
	A	B	C	D	E
1975-'79	75	18	14	30	8.1
1980-'84	82	18	6.7	48.7	9.7
1985-'89	88	21	5.1	43.2	8.4
1990-'94	92	31	4.8	61.4	6.6
1995-'99	88.1	31.6	9.0	63.1	3.2
2000-'04	93.2	39.4	5.7	55.9	*
2005-'09	90.0	31.3	9.1	51.9	5.3
2010-'14	95.4	25.5	3.2	45.9	4.9
2015-'19	93.8	25.5	5.8	47.0	1.3
2005	83.3	35.5	15.3	57.6	*
2006	82.2	36.1	16	54.4	*
2007	95	37.3	4.1	**	*
2008	93.2	26.9	6.8	**	5.6
2009	96.1	20.8	3.3	43.8	4.9
2010	98.1	13.5	1.3	34.2	10.1
2011	95.9	22.7	0.5	35.5	4.1
2012	96.7	20.8	2.8	54.7	3.6
2013	95.1	29.6	4.6	53.9	4.5
2014	91.3	40.7	6.7	51.4	2.4
2015	88.6	27.8	9.8	61.2	2.7
2016	93.8	18.8	6.3	26.6***	1.4
2017	96.1	20	3.4	42.1	1.6
2018	92.9	28.6	7.1	37.2	0.6
2019	97.5	32.3	2.5	47.4	0
2020	94.4	39.4	3.9	53.8	2.1

* no kelt tagging; ** see section 4.7 (2007 report)

*** Data compromised by Storm Desmond (see 2016 Report)

5 Reared Salmon Census Programme

A programme of rearing and releasing tagged salmon has been carried out in Burrishoole since the early 1960s. The stock was based originally on donor wild salmon from the Burrishoole system and the stock has been closed since using returning tagged fish as broodstock. Additional experimental groups are sometimes released and these are differentially tagged and sometimes freeze branded so as to distinguish them from the core ranched stock and avoid including them in the ranched broodstock. The ranched stock facilitates data collection and comparison with the wild stock without putting undue stress or mortality on the wild stock – in this report the components of the ranched stock are known as reared grilse (1SW) and reared 2SW salmon.

5.1 Coastal Returns

Details of coastal returns of Burrishoole fish are available in the Marine Institute 'National Report for Ireland - The 2020 Salmon Season' report.

5.2 Return rate of reared and wild grilse

A total of 1,399 nose-cores were recovered from reared fish returning to Burrishoole in 2020 consisting of 12 different microtag codes. Of these fish, 12 were identified as multi sea winter fish and 1,277 as one sea winter (grilse) and 110 had no tags.

The overall percentage return for reared grilse returning in 2020 was 6.5% which was considerably higher than the previous year at 3.3%.

The percentage return of wild grilse in 2020 was 10.6%, also an increase from 7.1% the previous year.

5.3 Recapture of Reared 2SW Fish

The total number of microtagged 2SW reared fish recorded returning to Burrishoole during 2020 was 12, comprising of 6 core release groups. The longest fish was 76.8 cm and the heaviest 4.5 kg.

5.4 Smolt Releases 2020

A total of 22,061 core ranched smolts were released from Burrishoole during 2020. They consisted of five individual microtag coded groups. All of the smolts were released into Lough Furnace. A total of 19,070 were released on 25/4/20 and the remaining 2,991 were released on 7/5/20.

For additional information on the rearing, see section 3.1.1.

Table 5-1: Details of microtag codes and smolt release groups 2020.

Group ID	Tag Code	Mean Wt	Mean Length	No. Released	Date Released
Core	470837	80.7	19.0	6290	25/04/2020
Core	470838	82.2	19.1	5846	25/04/2020
Core	470604	86.8	19.5	2991	07/05/2020
Core	470605	63.7	17.6	3715	25/04/2020
Core	470606	63.3	17.6	3219	25/04/2020

5.5 Reared kelts

Reared fish often move downstream throughout the late summer and autumn and these are collected for broodstock. A general cut-off date of the 1st December is used to separate these pre-spawned migrants and post-spawned kelts. However, some of the fish migrating downstream in December might not actually have spawned and might end up in the broodstock.

In 2017, 108 were released upstream during the summer. By the end of November 2017 a total of 53 ranched fish were recaptured in the downstream traps and transferred to the broodstock pond. In 2018, an additional 20 fish were recaptured in the downstream traps. Therefore, the total recapture from the 108 released upstream was 73 fish (67.6%).

In 2018, 143 were released upstream during the summer. However, it was noted that the number of ranched fish displaced downstream prior to the spawning season (179) was greater than the number of fish released upstream (143). In 2019, an additional 15 fish were recaptured in the downstream traps.

In 2019 a total of 117 ranched fish were released upstream and by December 2019, 117 were recorded in the downstream traps. However, an additional 22 ranched fish were recorded in the downstream traps during 2020. It is likely that some ranched fish escaped upstream unrecorded when the fish fence was over-topped in December.

In 2020, 158 were released upstream during the summer. It was estimated that 23 remained in the catchment during the spawning period (85% recovery). In 2021 a total of 15 ranched fish were recorded as kelts.

6 Wild Sea Trout Census Programme

6.1 Upstream Movements: Timing and Numbers.

A total of 36 wild silvered sea trout and a further 57 non-silvered trout migrated upstream through the traps in 2020. Of the silvered trout, 14 were adults and 22 (61%) were finnock. The numbers are compared with other years in Table 6.1. Of the total run of migratory (silvered and unsilvered) trout (93), 61% were unsilvered. For the purposes of this report, the unsilvered trout are not included with the sea trout. Table 6.1 shows that the numbers of sea trout have not recovered in the Burrishoole system and have shown a ten-fold drop since the 1970s.

The timing of the sea trout run in 2020, and in previous years, expressed in monthly percentages, is given in Table 6.2. The highest proportion of sea trout, both finnock and adults, moved upstream in June (52.8%) and July (38.9%). The unsilvered trout moved upstream from June through to December, with the highest proportions in June, July and August.

Table 6-1: Annual runs of sea trout recorded in the traps.

Year	Mill Race	Salmon Leap	Total	Amended Total
1970-74	1365	762	2127	
1975-79	829	1775	2604	
1980-84	458	780	1238	1719 *
1985-89	386	590	978	
1990-94	134	72	206	
1995-99	86	91	177	
2000-04	32	64	97	
2005-09	21	44	65	
2010	10	62	72	
2011	15	53	68	
2012	19	120	139	
2013	20	50	70	
2014	16	126	142	
2015	31	28	59	
2016	8	73	81	
2017	1	9	10	
2018	5	16	21	
2019	2	16	18	
2020	3	33	36	

* See Table 34, Ann. Rep. XXX (1985); p. 43.

Table 6-2: Timing of the Burrishoole (a) silvered sea trout run and (b) unsilvered trout run (in monthly percentages). (n = no. of trout).

(a) Silvered Trout

	1970-'79	1980-'84	1985-'89	1990-'94	1995-'99	2000-'04 (483)	2005-'09 (325)	2010-'14 (491)	2015 (59)	2016 (81)	2017 (10)	2018 (21)	2019 (18)	2020 (36)
May	-	0.2	0.5	0.1	3.1	2.0	1.3	3.2	0.0	6.2	0.0	0.0	0.0	0.0
June	13.1	24.6	9.4	8.4	8.6	16.7	9.0	6.1	6.3	21.0	20.0	9.5	16.7	52.8
July	54.4	44.9	62.2	55.0	42.4	37.5	32.5	54.0	75.0	58.0	60.0	4.8	44.4	38.9
Aug	15.8	10.3	18.4	16.5	19.3	26.4	38.1	22.3	18.8	12.3	10.0	76.2	38.9	8.3
Sept	7.6	14.8	3.7	8.5	9.8	5.7	13.6	7.8	0.0	1.2	10.0	4.8	0.0	0.0
Oct	6.4	3.5	4.1	7.9	12.2	10.2	4.7	4.9	0.0	1.2	0.0	4.8	0.0	0.0
Nov	2.4	1.5	1.5	2.9	4.3	1.5	0.7	1.6	0.0	0.0	0.0	0.0	0.0	0.0
Dec	0.3	0.2	0.2	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(b) Unsilvered Trout

	2005-'09 (408)	2010 (104)	2011 (87)	2012 (47)	2013 (101)	2014 (91)	2015 (79)	2016 (95)	2017 (53)	2018 (64)	2019 (75)	2020 (57)
April	1.4	0.0	3.4	0	1.0	3.3	1.3	0	0.0	4.7	1.3	0.0
May	7.2	1.0	5.7	0	3.9	9.9	3.8	29.79	0.0	6.3	10.7	0.0
June	12.4	0.0	3.4	21.7	6.9	12.1	2.5	25.53	11.3	17.2	10.7	24.6
July	18.3	44.2	12.6	17.4	9.9	30.8	34.2	14.89	37.7	3.1	21.3	15.8
Aug	20.5	16.3	14.9	13.0	34.7	4.4	20.3	12.77	9.4	26.6	14.7	19.3
Sept	9.6	17.3	11.5	13.0	9.9	3.3	7.6	9.574	15.1	14.1	9.3	12.3
Oct	15.7	7.7	11.5	19.6	24.8	25.3	12.7	2.128	11.3	18.8	20.0	7.0
Nov	10.2	11.5	36.8	6.5	5.0	6.6	13.9	4.255	7.5	4.7	6.7	14.0
Dec	4.8	1.9	0.0	8.7	5.0	4.4	3.8	1.064	7.5	4.7	5.3	7.0

6.2 Tag Recaptures in Upstream Migration

In total, four trout were detected with PIT tags in 2020. Of these, one was identified as brown trout (tagged in March 2017 in the catchment, one as a silvered finnock (from a 1+ autumn trout tagged in Nov, 2017) and two were detected on the main antenna in the Denil fish ladder but were not subsequently detected in the upstream trap (from one tagged as an autumn trout in 2017 and one as an ERC fish from the Rough River). The fate of these two is unknown as they were not picked up on the handheld detectors in the upstream trap.

TSU genetics samples were collected from 83 trout.

6.3 Spawning Escapement

With the continuation of the catch and release bye-law into the 2019 fishing season, no sea trout were reported killed by anglers on L. Feeagh in 2020. Using the upstream fish counts through the traps, the total maximum spawning escapement of migratory trout to the L. Feeagh catchment was 93, of which 75 were non-silvered sea trout (Table 6.3).

Table 6-3: Annual spawning escapement of sea trout into freshwater, 1970-2020.

	1970-'79	1980-'84	1985-'89	1990-'94	1995-'99	2000-'04	2005-'09	2010-'14	2015-'19	2019	2020
Max. Escap.	2090	1146	906	231	289	156	146	184	111	93	93
Revised	1622										

6.4 Downstream Movements, Sea Trout Smolts

The 2020 smolt run amounted to 92 wild smolts, of which 82 were released downstream (Table 6.4). An additional five smolts originating from the ERC Rough River experiment were also recorded. Few smolts were recorded from January to March. The smolt run period in 2020 was characterised by relatively low water levels, with the main migration occurring in May (65%) around a short modest increase in water level (Fig. 6.1).

The 2020 smolt count was the lowest smolt count recorded since the start of the full counts in 1971 (Table 6.5).

A total of 88 wild trout smolts were measured in 2020. Length measurements were taken to facilitate an estimated age breakdown of the smolt run. The estimated statistics for the 2020 smolts were a mean length of 19.8 cm and a range from 15.1 cm to 26.5 cm and the length frequency is presented in Figure 6.2 compared with that of 2018 and 2019. This gave an estimated age of 80.7% 2-year-old and 19.3% 3-year-olds.

6.5 Tagging and Recaptures in Spring Downstream Migration

In 2020, no wild sea trout smolts were PIT tagged in the downstream traps. 30 trout that had been previously tagged in the catchment were recorded and/or sampled in the downstream traps in 2020. Six of these were fish originated from the ERC project in the Rough River and 11 were of origin unknown (assumed wild).

17 were recorded as Brown trout (4 were in the spring, 3 in July/August and 11 were in the autumn).

12 were recorded as sea trout smolts, of which 5 were Rough River ERC and 7 were wild.

TSU genetics samples were collected from 282 trout moving downstream in 2020. Of these, 87 were wild sea trout smolts, 128 were brown trout in the first half of the year and 67 were brown trout in the second half of the year.

Table 6-4: Monthly numbers of Burrishoole sea trout smolts recorded through the traps.

Month	Salmon Leap	Mill Race	Total	%
January	0	0	0	0.0
February	0	0	0	0.0
March	15	0	15	16.3
April	10	3	13	14.1
May	38	20	58	63.1
June	5	1	6	6.5
July	0	0	0	0.0
Total	68	24	92	
Number Released Downstream			87	

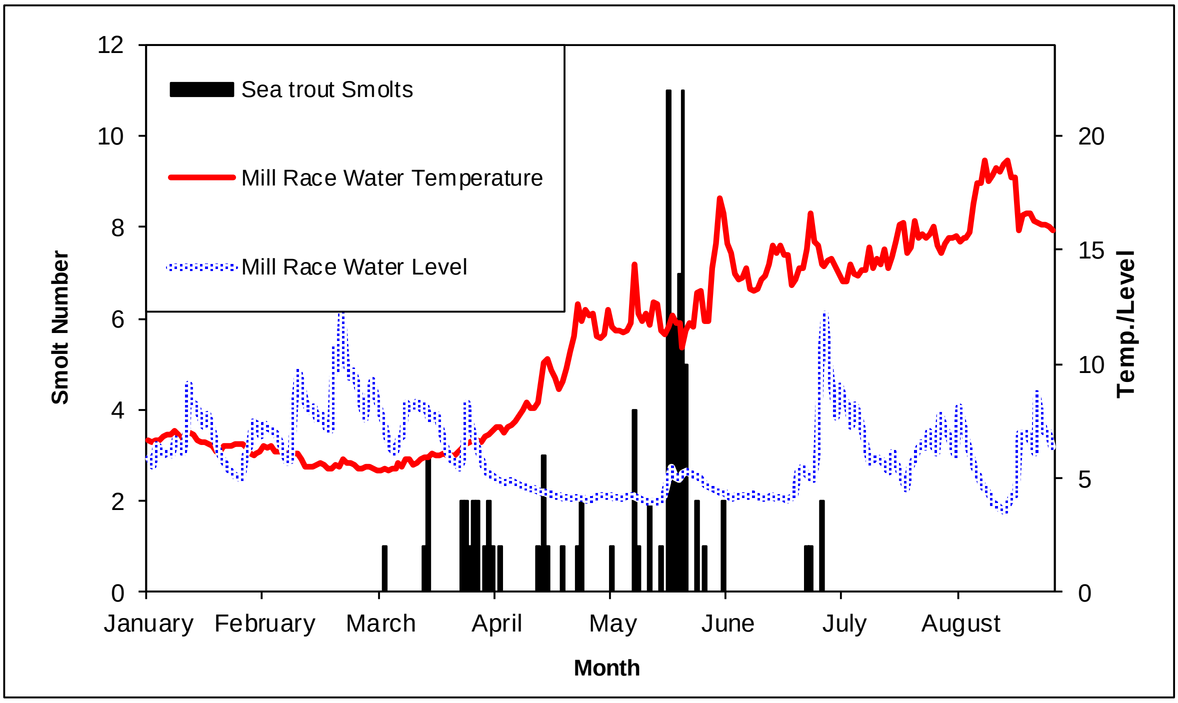

Figure 6-1: Timing of the 2020 wild sea trout smolt migration with daily midnight water level (m x 10) and midnight temperature (⁰C - OTT).

Table 6-5: Annual sea trout smolt numbers in Burrishoole for 1970 to 2020.

	1970-79	1980-84	1985-89	1990-94	1995-99	2000-04	2005-09	2010-'14	2015-'19	'18	'19	'20
Number of Smolt	4176	4038	4119	1531	1361	816	609	475	336	362	243	92
Number sacrificed				144	35	24	6	10	6	0	24	5

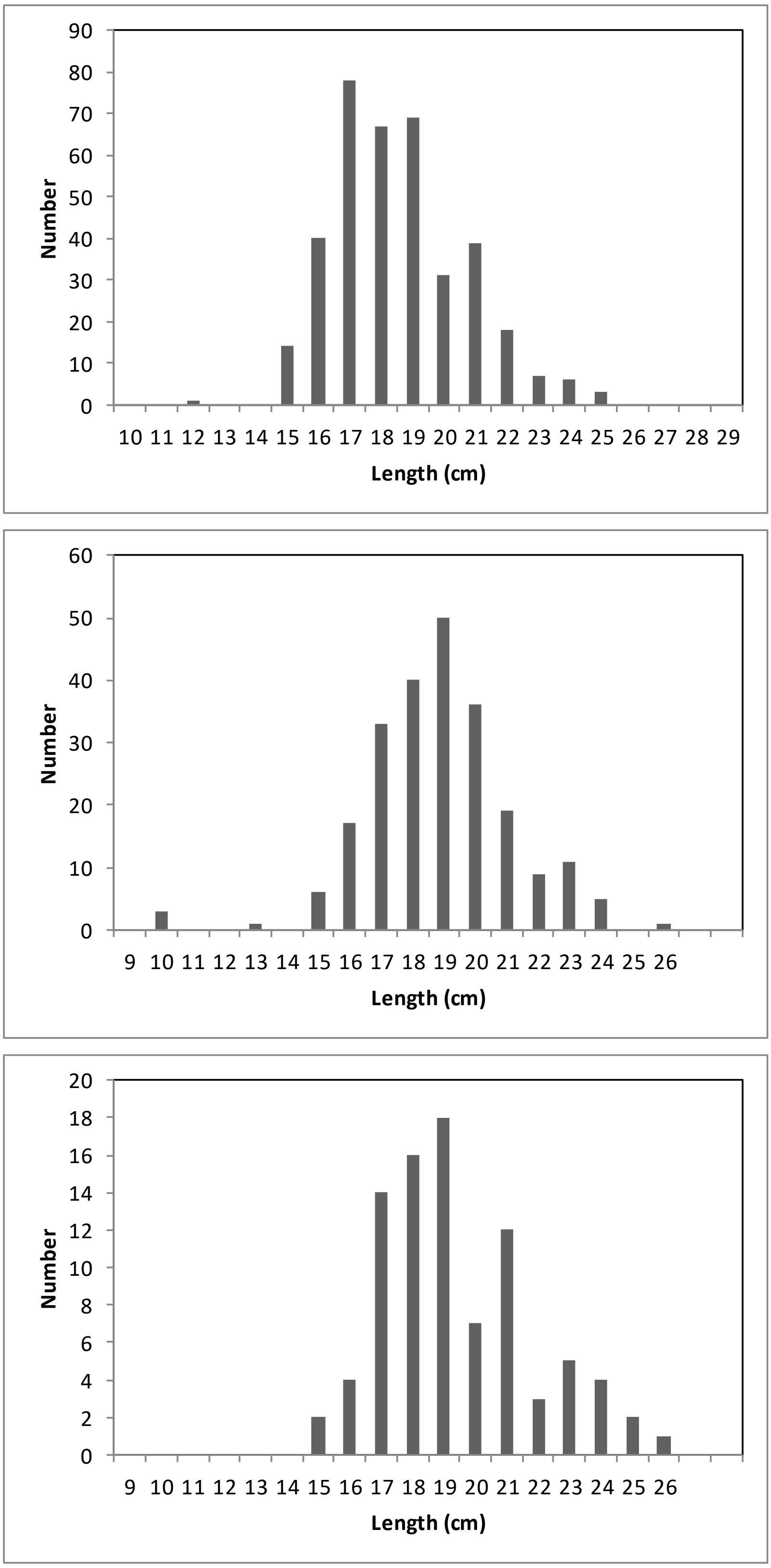

Figure 6-2: Length distributions for smolts in the Burrishoole system, top graph 2018 (n=373), middle graph 2019 (n=3231) and bottom graph 2020 (n=88). Note also change of x-axis scale from the 2018 report.

6.6 Autumn Migrating Smolts

These are juvenile trout (*Salmo trutta* L.) which generally move downstream through the traps from August to December. It is not clear whether these are true sea trout or part of the resident trout stock being displaced downstream. It is known through mark-recapture studies that a proportion of the 1+ autumn trout do return the following year as silvered finnock. These runs of trout would appear to becoming more prolonged with substantial numbers of un-silvered 0+ and 1+ trout continuing to migrate downstream in the early months of the year.

A total of 830 juvenile trout entered the downstream traps between July 2020 and May 2021 (Table 6.6). The percentage of 0+ trout that migrated over the period was 29.2% (Table 6.7).

6.7 Tagging and Recaptures in Autumn Downstream Migration

In 2020 autumn trout were not PIT tagged in the downstream traps. See Sec. 6.5 for tags and recaptures.

TSU genetics samples were collected in 2020 (up to end of May 2021), see Section 6.5).

Table 6-6: Numbers of migrating autumn juvenile trout in 2020, to the end of May 2021.

	0+		1+		Total	
Month	Salmon Leap	Mill Race	Salmon Leap	Mill Race	Salmon Leap	Mill Race
July	2	1	16	8	18	9
August	1	0	9	1	10	1
September	7	0	47	1	54	1
October	64	5	167	16	231	21
November	91	6	204	27	295	33
December	20	2	30	11	50	13
January '21	10	0	16	4	26	4
February '21	7	0	5	1	12	1
March '21	12	2	6	2	18	4
April '21	5	2	5	1	10	3
May '21	5	0	10	1	15	1
Total	224	18	515	73	739	91
Overall Total	**242**		**588**		**830**	

Table 6-7: Percentage of 0+ juvenile trout (<10cm) in the trapped autumn migrating trout.

Year	% 0+	Year	% 0+
1982	50.0	2002	32.8
1983	N/A	2003	48.9
1984	55.8	2004	35.5
1985	30.3	2005	37.3
1986	16.1	2006	51.2
1987	35.3	2007	27.9
1988	60.9	2008	28.2
1989	37.2	2009	25.0
1990	35.2	2010	34.9
1991	26.0	2011	37.6
1992	38.2	2012	47.3
1993	27.6	2013	36.1
1994	16.8	2014	36.6
1995	25.3	2015	27.2
1996	34.0	2016	46.4
1997	18.7	2017	37.0
1998	33.5	2018	31.2
1999	42.0	2019	35.5
2000	47.8	2020	29.2
2001	56.3		

6.8 Total Recruitment

The 0+ autumn trout will not be large enough to become sea trout smolts in the following spring. The remainder, predominantly 1+ year olds, could contribute to the overall recruitment of sea-run trout the following year. The exact proportion of 1+ autumn trout that become smolts in any given year is not known. It is only since 1982 that the proportion of 0+ trout amongst the autumn migration has been estimated. Thus the figures for total recruitment up to this time are over-estimated (Table 6.8).

From 1982, total recruitment was calculated by adding the number of sea trout smolts produced in any one year to the total of 1+ autumn trout the previous year (Table 6.9). The assumption is made that all the 1+ autumn trout will become sea trout smolts and that no 0+ trout from the two years previous will be recruited as smolts. The fate of 1+ unsilvered juveniles migrating down in January to May is unknown but seems unlikely these will contribute to the 2+ spring smolt migration.

Table 6-8: Estimates of total migrant trout recruitment up to 1981.

Year	Smolt Total	Autumn trout (preceding year)	Total Recruitment
1970-74	4450	2870	6746
1975-79	4314	3186	7489
1980	2337	2351	4688
1981	6710	2631	9341

Table 6-9: Estimates of total migrant trout recruitment from 1982 to date.

Year	Smolt Total	1+ Autumn trout (preceding year)	Total Recruitment
1982-84	3714	1203	4917
1985-89	3706	1063	4778
1990-94	1788	399	2187
1995-99	1361	498	1860
2000-04	816	578	1377
2005-09	610	449	1059
2010	213	267	480
2011	620	501	1121
2012	632	493	1125
2013	485	536	1021
2014	427	351	778
2015	426	481	907
2016	356	334	690
2017	291	365	656
2018	362	436	798
2019	243	656	899
2020	92	413	505

6.9 Marine Survival

An estimate of sea trout survival to first return to freshwater can be more accurately calculated by the use of trap census data rather than rod catch returns of tagged or marked fish. Small numbers of stray fish are captured in other systems and it is not known whether these fish would have returned to their natal systems to spawn. Finnock are known to wander between river systems and are therefore not as reliable for assessing survival.

The pattern of marine survival found is similar whether the number of smolts is used or the combined total recruitment of smolts and autumn 1+ trout. The percentage of smolts that return as finnock (0+ sea age) in the same year historically ranged from 11.4% to 32.4% (Fig. 6.3). In 1988 it fell below the previous recorded minimum to 8.5% and in 1989 to a minimum of 1.5%. There has been a saw-tooth pattern of finnock return in the 1990's rising to 16.7% in 1999, 18.1% in 2009 and 17.5% in 2010 – the highest return rates since 1986. These increases were not, however, always sustained in subsequent years and there was a collapse in 2005 down to 1.5%. This was associated with the heaviest infestations of sea lice observed in the Burrishoole area since 1992. The return of smolt as finnock in 2011 was 5.8%, 13.8% in 2012, 11.0% in 2013 and 29.5% in 2014 – the highest recorded level since the mid-1970s. The return in 2020 was 25.3%.

The total survival of smolts to their first return to freshwater as finnock in the same year and one year old sea trout in the following year (always an over-estimate as a proportion of finnock re-entering freshwater in year 1 return as sea trout in year 2 (Mills *et al*, 1990)) also showed a drop in survival from 1987 to 1989 (Fig. 6.4).

Historically, the total survival to first return ranged from 19% to 66%. This collapsed to 1.8% in 1989 but rose to 12.1% in 1990. However, little further improvement was recorded in 1991 (12.8%). Marine survival fell to the second lowest level in 1992 but returned to 13.2% for the 1993 year class of smolts.

There was a further increase in 1994 to 17.0% but a drop in 1995 to 8.4%. There were marginal improvements again in 1996 (12.8%) and 1997 (13.1%), a drop to 8.3% in the 1998 year class and a marked improvement in the 1999 year class where marine survival was 20%, the highest recorded in 12 years and back within the pre-collapse historical range. Total survival increased for the 2009 cohort to the highest recorded level since 1988 of 23% and to 23.2% for the 2010 cohort. For the 2011 cohort of smolts, it was 10.2% and for the 2012 cohort it was 17.1%. In 2013 it was 14.4% and rose to 33.0% in 2014 but following the fall in finnock return in 2015 the total return in 2016 fell to half that of the previous year. The total return of 2019 smolts in 2020 was 11.4%.

NOTE: The data used in Chapter 6.6 have been updated in 2014 following a comprehensive data quality control project. None of the changes were significant and the main changes were in 2011 and 2012 following a reclassification of trout considered to be silvered and unsilvered.

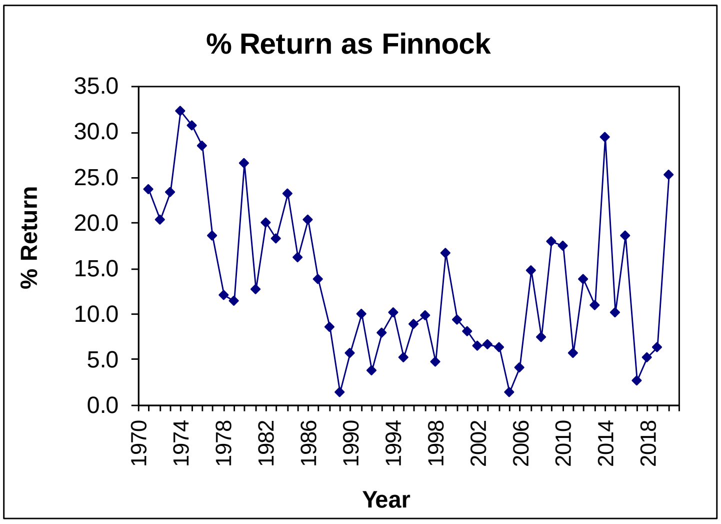

Figure 6-3: Annual percentage return of smolts returning as finnock to the Burrishoole system.

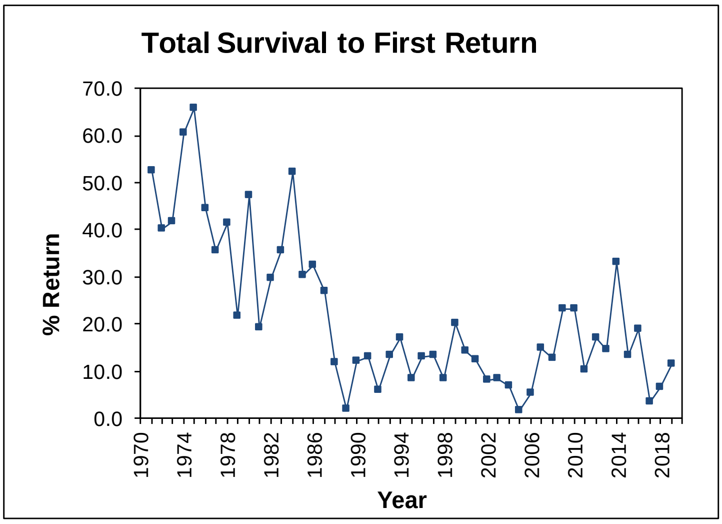

Figure 6-4: Annual marine survival of smolts to first return (as finnock and 1+ sea trout) to the Burrishoole system.

6.10 Sea Trout Kelts

Table 6.10 gives the numbers of sea trout and brown trout kelts, both spawned and immature, counted downstream in the winter of 2019 and spring of 2020.

The freshwater survival of kelts is given in Table 6.11. In some years, the number of kelts migrating downstream has exceeded the number of upstream migrants. This occurred in the early '80s when the screen allowed finnock to escape. This was rectified. More recently, the difficulty in separating small finnock and large smolts has led once again to a discrepancy as shown in Table 6.11. In addition to the size overlap, trout counted upstream as unsilvered migrants may be counted downstream as silvered kelts, and immature autumn downstream migrants may be misidentified as brown trout kelts, both causing additional difficulties in making survival estimates.

Since 1987, only one survival rate has been given for all sizes as it has been shown that a proportion (at least 33%) of the sea trout population may over-winter in freshwater. These fish do not spawn and continue to grow. There is also the additional complication of larger smolts and reduced sea growth mentioned above. Thus the comparisons of the proportion of fish in different year classes between the upstream migrants of one year and the downstream migrants of the next are invalidated.

In 2019/20, overall sea trout kelt survival was 61.1% and for finnock only (small sea trout) it was 50%. These survivals were relatively low compared to previous years. However, there was once again an unusually high unsilvered (BT) count downstream so some of these may account for additional sea trout. The total downstream count of sea trout and BT was 141, from an upstream count in 2019 of 75 fish. It is not known what effect the unusual spring and summer conditions of 2017, 2018 and 2019 had on smolting, silvering and survival rates.

Table 6-10: Timing and numbers of sea trout kelts for the 2019/2020 season.

Month	Large ST	Small ST	BT	Total ST	Total Trout
October '19	0	0	11	0	11
November	0	0	10	0	10
December	0	0	53	0	53
January '20	0	1	11	1	12
February	2	2	14	4	18
March	2	0	22	2	24
April	0	1	2	1	3
May	0	3	3	3	6
June	0	0	4	0	4
Total	**4**	**7**	**130**	**11**	**141**

Table 6-11: Annual survival rate to sea trout kelt, as % of the upstream escapement of the previous year.

Year	Larger (> 30.0 cm)	Small (< 30.0 cm)	Year	Larger (> 30.0 cm)	Small (< 30.0 cm)
1976	79	66	2000	70.10%	"
1977	63	45	2001	82.00%	" *
1978	50	66	2002	129.60%	" *
1979	33	107*	2003	66.10%	"
1980	50	82	2004	120.50%	"*
1981	44	345*	2005	142.20%	"*
1982	53	203*	2006	110.50%	"
1983	63	177*	2007	228.90%	"**
1984	74	210*	2008	98.90%	"**
1985	70	98	2009	107.50%	"*
1986	66	72	2010	59.40%	"
1987	58.70%	(combined)	2011	88.90%	"*
1988	65.50%	"	2012	117.65%	"*
1989	68.70%	"	2013	161.33%	"*
1990	79.00%	" *	2014	87.14%	"
1991	98.70%	" *	2015	92.81%	"
1992	89.50%	" *	2016	115.30%	"*
1993	96.70%	" *	2017	48.20%	"
1994	104.60%	" *	2018	30.00%	"
1995	96.20%	″ *	2019	47.60%	"
1996	127.70%	" *	2020	61.11%	"
1997	97.00%	" *			
1998	140.10%	" *			
1999	110.40%	" *			

* Years when the number of finnock kelts counted downstream exceeded the number counted upstream during the previous season.

7 Eel Census Programme

7.1 Silver Eel Numbers

The total run amounted to 2122 eels, higher than recorded in 2018 but a little lower than in 2019. As in other years, the highest proportion of the total catch (86%) was made in the Salmon Leap trap.

There was only one large flood event in the silver eel season in 2020, which followed a relatively long period through August and September into mid-October when water levels were relatively low. Forty-two percent of the eels were counted in the three days of the flood in mid-October (Figure 7.1).

In 2020, the timing of the run was 11% migrating in August, 9% in September and 69% in October (Table 7.1). Almost 90% of the run was completed by the end of October with the remainder in November. Figure 7.1 shows the daily counts of silver eels.

Table 7-1: Timing and numbers of the 2020/'21 silver eel run.

	Salmon Leap	Mill Race	Total	%
May	0	0	0	0.0
June	0	0	0	0.0
July	29	16	45	2.1
August	171	53	224	10.6
September	153	37	190	9.0
October	1293	156	1449	68.3
November	164	30	194	9.1
December	13	1	14	0.7
Jan. 2021	3	0	3	0.1
February	0	0	0	0.0
March	2	0	2	0.1
April	0	1	1	0.0
Total	1828	294	2122	

7.2 Silver Eel Size

Sampling of individual eels (n = 555) gave an average length of 43.7cm (range: 29.7 – 99.8cm) and an average weight of 179g and the proportion of male eels was 36.4% (Table 7.2. The length frequency is presented in Figure 7.2 along with those 2018 and 2019 for comparison. The lack of eels above 46/47cm (now 44/46cm) was once again notable.

Counts of silver eel between the years 1971 (when records began) and 1982 averaged 4,400, fell to 2,200 between 1983 and 1989 and increased again to above 3,000 in the '90s (Fig. 7.3). There was an above average count in 1995, possibly contributed to by the exceptionally warm summer. The count in 2001 of 3875 eels was the second highest recorded since 1982. The average weight of the eels in the samples increased from 95 g in the early 1970s to 216 g in both the 1990s and the 2000s (Fig. 7.3). This has dropped again to an average of about 175g in the last three years.

In 2012, the majority of the eel run was sampled (n=3317; 99.5%). The run increased from 1969 in 2011 to 3335 in 2012 and the average weight decreased from 180 to 163.5g. The sex ratio changed from 24% to 45% over the past five years. Male eels have remained the same length over the past 15 years (36cm) whereas the females have changed from 53cm (1997-2005) to 50cm (2008-2012). The silver eel biometric data have been published in Poole et al. (2018).

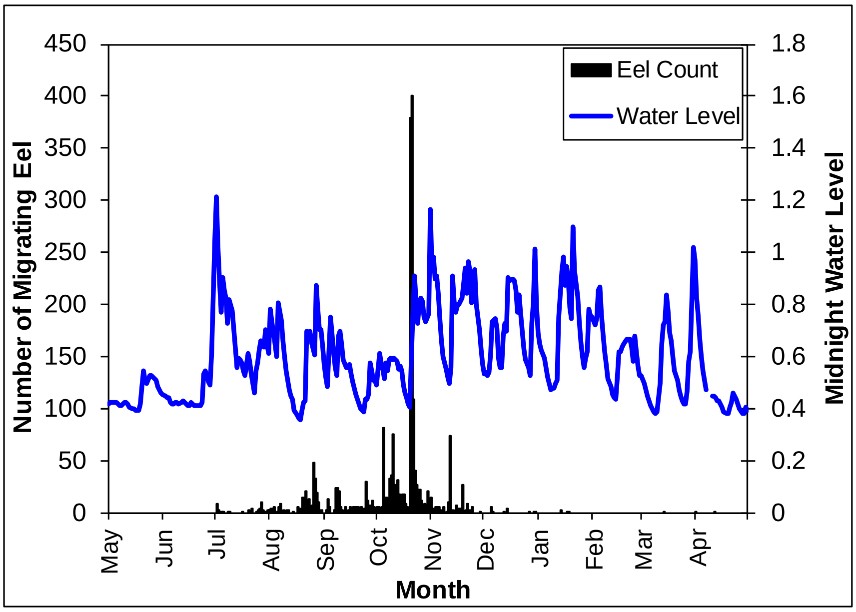

Figure 7-1: Daily counts of downstream migrating silver eel and mid-night water levels (m), May 2020 to April 2021.

Table 7-2: Comparative data for the silver eel runs since 1971.

Years	Number Sampled	Mean. Weight (gm)	% Male Statistical[1]
1971 - '75	4465	84	
1976 - '80	4023	115	60.4
1981 - '85	2678	171	47.9
1986 - '90	11658	196	40.5
1991 - '95	3441	227	29.2
1996 - '00	3958	212	34.5
2001 - '05	3201	215	33.5
2006	493	225	23.0
2007	571	201	39.9
2008	796	234	23.8
2009	220	209	34.9
2010	982	192	35.5
2011	1835	180	40.1
2012	3315	163	45.2
2013	1301	157	45.7
2014	650	196	32.2
2015	366	192	44.7
2016	554	177	36.5
2017	481	177	34.7
2018	573	178	40.8
2019	637	170	42.1
2020	555	179	39.5

1. Sex ratio calculated using Bhattacharya (1967) method

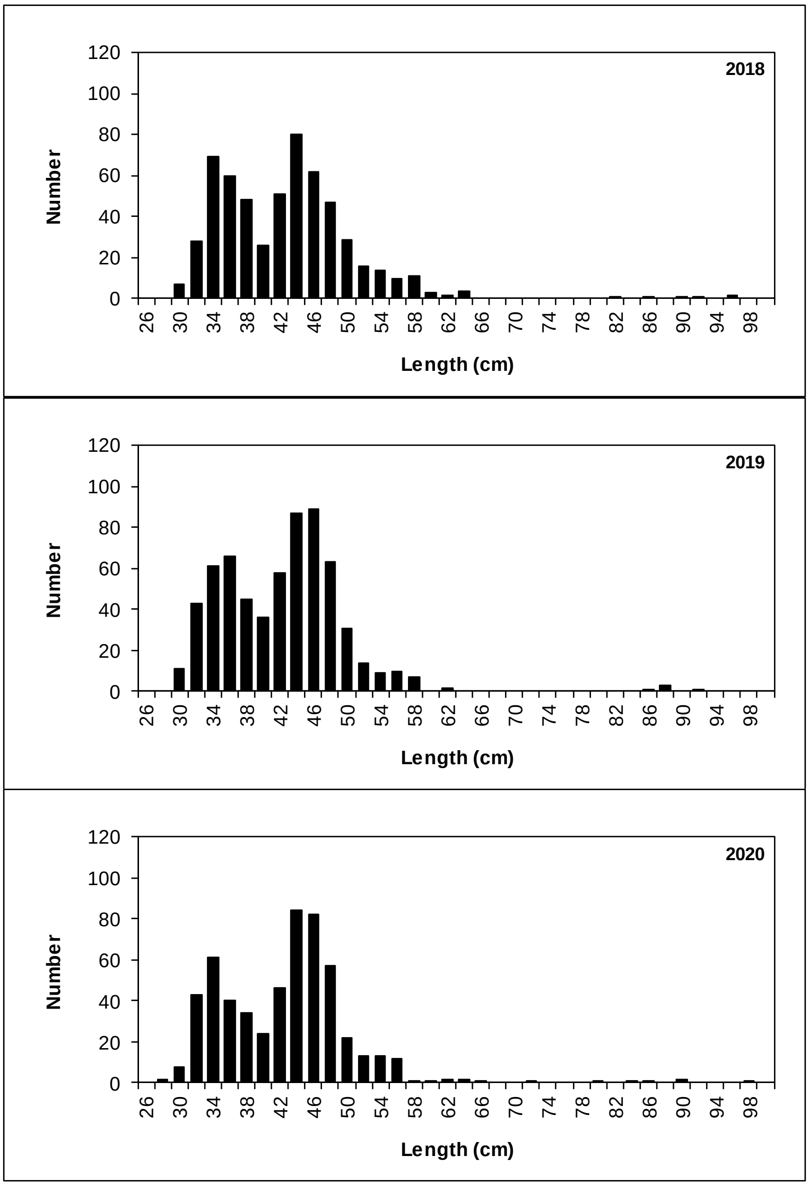

Figure 7-2: Length frequency of samples of silver eels trapped in the Burrishoole downstream traps, 2018 (573), 2019 (637) and 2020 (555).

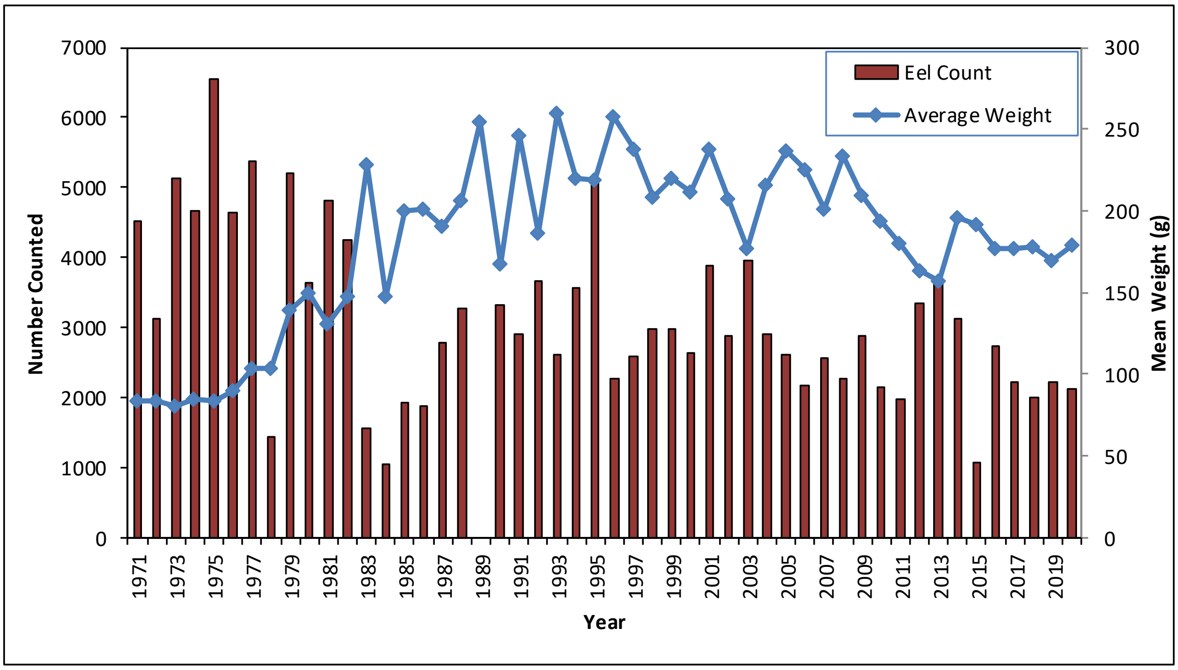

Figure 7-3: Annual number and mean weight (g) of silver eels trapped in the downstream traps.

7.3 Elvers

In 2007, a small O'Leary style elver trap was installed in the outflow of the large release pond in Furnace. This provides some indicative data of the relative annual abundance of young eel recruitment. By numbers, the catch is predominantly zero age class glass eel ("elvers") of various levels of pigmentation, but by weight the young yellow eels moving out of Lough Furnace make a more significant contribution. These young yellow eels are predominantly ages one to four. Figure 7.4 gives the annual weight of recruits trapped and compares with catches in a similar trap in the 1980s. These current levels are about 10 times lower than those of the 1980s in the same location. 2020 was the 3rd highest year over the last decade.

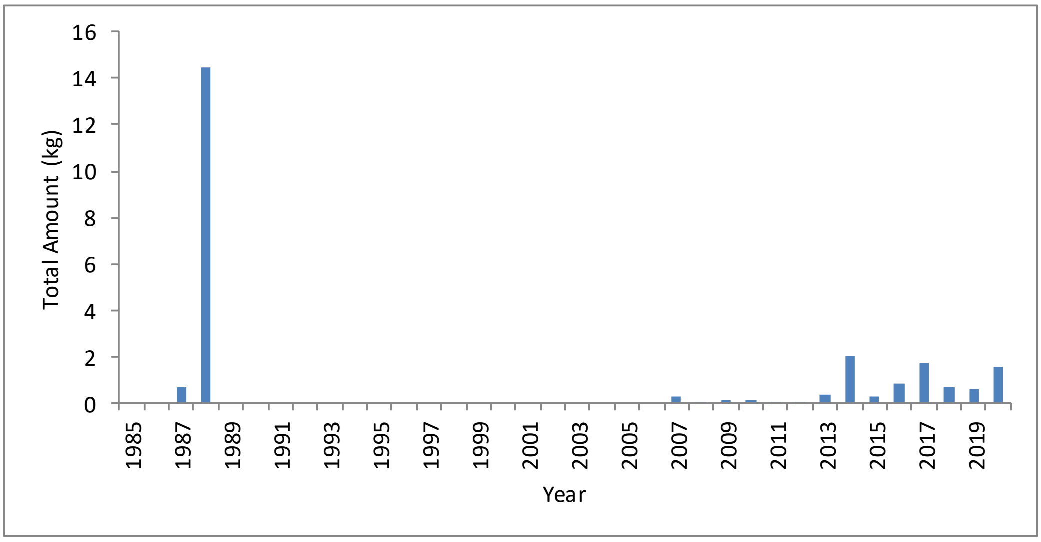

Figure 7-4: Annual catch (kg) of eel recruits (glass eel and young yellow eel) in the Mill Race elver trap.

8 Fishery Report - Catch Data

The Burrishoole Fishery is a valuable part of the overall stock census programme and is run as an integral part of the monitoring programme. As part of the conservation of the Burrishoole wild stock, changes to the active season and to the parts of the catchment being fished have caused differences, or gaps, in the data being collected. Lough Feeagh, which had been closed to angling since 1997 for conservation reasons was opened to angling for the month of September in 2008, on a catch and release basis for wild fish. In 2009 - 2013 Lough Feeagh was open for angling on a catch and release basis from August to the end of September and in 2014 for one week only from 24th August due to low stock. During 2017 Lough Furnace was open from June 14th to September 30th. Lough Feeagh was closed under a conservation byelaw. During 2018 and 2019 Lough Furnace was open from June 15th to September 30th. Lough Feeagh opened on the 3rd September in 2018 and from the end of August for just one boat in 2019. Since 2018, the fishery was operated on a 7-day week and on a catch and release basis for both wild salmon and sea trout.

In 2020, due to COVID-19 travel restrictions, it was decided not to open the fishery in 2020.

Refer to the 2019 Report for the tables of catch, exploitation and CPUE.

9 Catchment Stock Assessment

9.1 Introduction

The Burrishoole catchment, upstream of the main fish traps, has been monitored since 1990 with surveys of the salmonid and eel stocks taking place in the rivers and the main lakes. Electrofishing, with 3-fishing depletions, is used for salmonids and eels in the streams, fine mesh beach seines are used for salmonids in the lakes and summer fyke nets are used for eels in the lakes. Eel surveys are also undertaken in the tidal waters below the traps.

9.2 Electrofishing Surveys

2020 marked the completion of 30 years of electrofishing surveys in the Burrishoole and Owengarve catchments, although fishing effort was markedly reduced in 2020 owing to the global Covid 19. We prioritized 13 sites for electrofishing with a reduced crew (3 people). Densities of eels and juvenile salmonids were calculated using three pass removal sampling.

Sites were fished on the 21st and the 23rd August 2020. A total of 656 fish were caught and measured over the 13 sites. The 22 sites comprised 1196 m^2 of representative habitat. Summary data are presented in Figures 10.1-10.6, and these show the distribution of fish densities around the catchment for eel (Fig. 9.1), 0+ salmon (Fig. 9.2), 1+ salmon (Fig. 9.3), 0+ trout (Fig. 9.4), 1+ trout (Fig. 9.5) and 2+ trout (Fig. 9.6).

The average eel density was 0.02 fish/m^2, with eels recorded in 5 sites out of 13.

Average density of 0+ salmon was 0.216 fish/m^2, with catches recorded in 5 sites. 1+ salmon were also recorded in 5 sites, with an average density of 0.02 fish/m^2.

Average densities of 0+, 1+ and 2+ trout were 0.36, 0.09 and 0.04 fish/m^2 respectively. 0+ and 1+ trout were recorded in 12 out of 13 sites, while 2+ trout occurred in 9 sites.

Average densities of 0+ trout were similar to those recorded in previous years. (Fig. 9.7), as were the densities of 0+ and 1+ salmon.

9.3 Beach Seine Surveys

Beach seine surveys were not conducted in 2020 due to COVID-19 restrictions.

9.4 Fyke Net Surveys

9.4.1 Survey Data

Fyke net surveys of yellow eels have been conducted in the 1970s and 1980s as parts of previous studies. The Burrishoole lakes Feeagh and Bunaveela have been incorporated into the National Eel Survey in 2009-2020. Fyke net surveys of the tidal Lough Furnace and 'Back of the House' have been more sporadic or at a lower effort.

Yellow-eel stock monitoring is integral to gaining an understanding of the current status of local stocks and for informing models of escapement. Such monitoring also provides a means of evaluating post-management changes and forecasting the effects of these changes on silver eel escapement. The monitoring strategy aims to determine, at a local scale, an estimate of relative stock density, the stock's length, age and sex profiles, and the proportion of each length class that migrate as silvers each year.

Fyke net surveys carried out between 1960 and 2008 provide a useful bench mark against which to assess the changes in stock. The yellow eel monitoring strategy will rely on the use of standard fyke nets. Relative density will be established based on catch per unit effort.

Bunaveela Lough is located in the upper reaches of the catchment. It has a surface area of 42ha and a maximum depth of 23m. Bunaveela L. was not fished in 2020 due to COVID-19 restrictions.

Lough Feeagh has a surface area of 395ha and an average depth of 14.5m (with several areas >35m in depth). L. Feeagh was fished in the traditional style (sets of 10 nets perpendicular to the shore) in 2020 on one night (27 August 2020), with chains of 10 nets fished at three sites for one night each. Note this was a reduced survey due to COVID-19. In total, 24 eels were caught with a catch per unit effort (CPUE) of 0.8 eels/net/night (Table 9.1). The average length of eels was 40.5cm and ranged in length from 30.4cm to 52.7cm (Figure 6.3), with a total weight of 3.01 kg caught in the two nights.

The catch was not PIT tagged and one previously tagged eel was recorded. No eels were sacrificed in this survey.

Lough Furnace, the tidal lough, has a surface area of 125ha north of Nixon's Island and 16ha between Nixon's Island and the mouth of the estuarine river (Lower Lough Furnace) (Figure 6-11). The main lough has a maximum depth of 21.5m. Furnace is heavily stratified with significant areas of deoxygenated water in the main basin. L. Furnace was fished in the traditional style (sets of 10 nets perpendicular to the shore) for two nights in 2020 (1-2 Sept), with chains of 10 nets fished at six sites in one night each. Fishing was also done in conjunction with the GMIT EMFF funded food web project.

In L. Furnace, 65 eels were caught with a catch per unit effort (CPUE) of 1.08 eels/net/night (Table 9.1). The average length was 40.4 cm ranging from 30.6 cm to 69.7 cm (Figure 6.12). A total weight of 7.93 kg was caught. Thirty eels were sacrificed in this survey from Lough Furnace for the GMIT Food Web project. Twenty-seven eels were examined for A. crassus, of which 14 (48.1%) of the eels contained *A. crassus* with an infection intensity of 4.2. *A. crassus* has been established in the lough since about 2011.

Lower Lough Furnace (BOH) was not fished in 2020 due to COVID-19.

Table 9-1: Catch details of the standard yellow eel survey in 2020. *Net (pair of traps).

Lake	Dates	No. Eels	Net* Nights	CPUE	Total weight (kg)	Mean length (cm)	Mean weight (Kg)
Bunaveela	Not Fished	-	-	-	-	-	-
Feeagh	27/08/2020	24	30	0.80	3.01	40.5 (30.4-52.7)	0.126
Furnace	1-2/09/2020	65	60	1.08	7.93	40.4 (30.6-69.7)	0.122
Lwr Furnace BOH	Not Fished	-	-	-	-	-	-

9.4.2 *Anguillicola crassus*

Anguillicola crassus is an indigenous parasitic nematode of the Japanese eel *Anguilla japonica* in Asia. *A. crassus* does not cause serious pathological damage in its natural host. However, infections in European eel are potentially more serious and can cause damage to the swimbladder with associated bacterial damage, red and swollen anus, as well as, in most severe cases, the collapse of the swimbladder lumen.

A. crassus was introduced into Europe in the early 1980s and it has since spread widely and has successfully colonized most European countries. It was first recorded in Ireland (Waterford Harbour) in 1997. Later records came from the Erne catchment in 1998 and it is now present in approximately 74% of the wetted area of Ireland. The most likely infective route to Ireland was the commercial eel trade although localised spread can be through natural eel movements and paratenic hosts.

The Burrishoole catchment remained free of the parasite until recently. In the fyke net survey in 2012, samples of yellow eels captured in L. Furnace (saline) and at the Back of the House (tidal lough below L. Furnace) were found to be infected with *A. crassus.* Samples of yellow eels from L. Feeagh were negative and a comprehensive sample of silver eels from the traps was also negative indicating that in 2012 the infection seemed to be confined to the tidal lough. This was somewhat surprising as a number of environmental factors have been shown to influence *A. crassus* infections. High salinity has been shown as having a negative impact in the egg hatching and larvae survival of the parasite although the effects of water salinity remain unclear as various surveys have shown no differences in infection levels in waters with different salinity values.

Examination of previous samples would indicate that the parasite was likely to have been introduced into L. Furnace in 2010 or early 2011 (Table 9.3).

The infection intensity in L. Furnace eels continued to rise in 2014 and it was also detected in yellow eels in the Mill Race channel in 2014. The prevalence in 2017 remained at 67% although the intensity increased to 20.7.

The first detection in freshwater was made in 2016 with 10 silver eels (36%) migrating out of the catchment containing the parasite (Table 9.3).

In 2017, the infection had increased to 67% in Lough Feeagh and 65% in the out-migrating silver eels, which had an intensity of 7.2.

In 2018, the infection in freshwater was similar to that in 2017. In saline water, the prevalence was lower in Furnace and a high prevalence was observed in a sample of 6 eels taken from the Back of the House. One eel in the estuary was also infected.

In 2019, the infection rates continued to rise in freshwater with prevalences of 88.4 (silver eels) and 83.3 (Feeagh Yellow). Tests using faecal washes indicated that the parasite has spread to Bunaveela in the headwaters of the catchment where 8 out of 25 (32%) tested positive (Michele de Noia, pers com). In 2019 an eel PIT tagged in Bunaveela was recorded with 2 worms confirming the presence of the parasite in the lough. There was not much change in 2020. A sample of bootlace eels from the elver trap in 2020 included an eel with crassus, confirming a likely vector from Furnace upstream into Feeagh.

9.5 Long-term biological monitoring in the Burrishoole catchment

Macroinvertebrate surveys of 14 index sites were conducted in 2020. Individuals from 42 samples were counted and identified, and are recorded in the Catchment Macroinvertebrate Access database for future analysis. Zooplankton and phytoplankton surveys of Feeagh and Furnace were continued in 2020, with monthly samples being collected using standard methods, and preserved for future enumeration and identification. All Feeagh zooplankton (2004-2020) and phytoplankton (2008-2020) samples have been processed, and data collated.

Table 9-2: Location and sample details for eels in Burrishoole examined for the presence of *Anguillicola crassus*.

Year	Location	No. of eels checked	Stage	No. Infected	Prevalence	Intensity
Freshwater						
2009	Traps	50	Silver	0	0	0
2010	Yellow R.	5	Yellow	0	0	0
2010	Black Lakes	3	Yellow	0	0	0
2010	Glenamong R.	3	Yellow	0	0	0
2010	Feeagh	2	Yellow	0	0	0
2010	Traps	17	Silver	0	0	0
2011	Traps	50	Silver	0	0	0
2011	Feeagh	30	Yellow	0	0	0
2012	Feeagh	4	Yellow	0	0	0
2012	Traps	168	Silver	0	0	0
2013	Traps	106	Silver	0	0	0
2014	Traps	94	Silver	0	0	0
2014	Mill Race Lwr	7	Yellow	4	57.1	2.3
2014	Mill Race Uppr	11	Yellow	2	18.2	1.0
2015	Traps	10	Silver	0	0.0	0.0
2016	Traps	28	Silver	10	35.7	2.0
2017	Feeagh	6	Yellow	4	66.7	2.5
2017	Traps	26	Silver	17	65.4	7.2
2018	Feeagh	6	Yellow	4	66.7	4.0
2018	Traps	53	Silver	36	67.9	7.0
2019	Traps	43	Silver	38	88.4	14.2
2019	Feeagh	12	Yellow	10	83.3	6.9
2020	Traps	17	Silver	14	82.4	7.9
Saline Water						
2008	Furnace	60	Yellow	0	0	0
2009	Fu Nixons	47	Silver	0	0	0
2010	Furnace	10	Yellow	0	0	0
2010	Fu Nixons	50	Silver	0	0	0
2011	Furnace	4	Yellow	2	50.0	1.0
2012	BOH	6	Yellow	6	100.0	2.0
2012	Furnace	10	Yellow	7	70.0	4.4
2013	Furnace	6	Yellow	6	100.0	13.5
2014	Furnace	9	Yellow	5	55.6	17.6
2016	Furnace	12	Yellow	8	66.7	2.7
2017	Furnace	6	Yellow	4	66.7	20.7
2018	Furnace	6	Yellow	1	16.7	13.0
2018	BOH	6	Yellow	5	83.3	7.6
2018	Estuary	5	Yellow	1	20.0	5.0
2019	Furnace	12	Yellow	6	50.0	3.8
2020	Furnace	27	Yellow	14	48.1	4.2

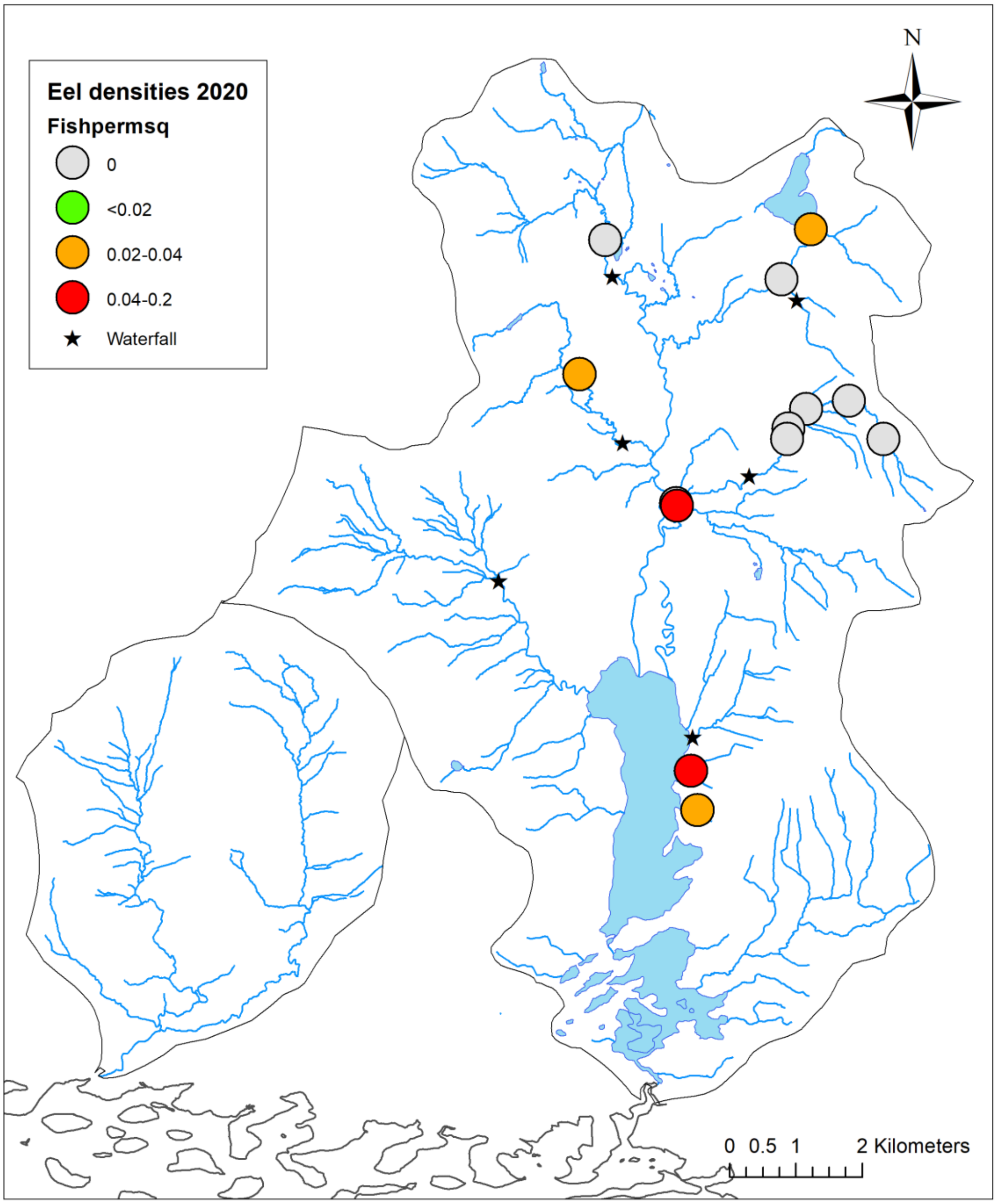

Figure 9-1: Densities of eel calculated from the 2020 electrofishing survey of the Burrishoole catchment.

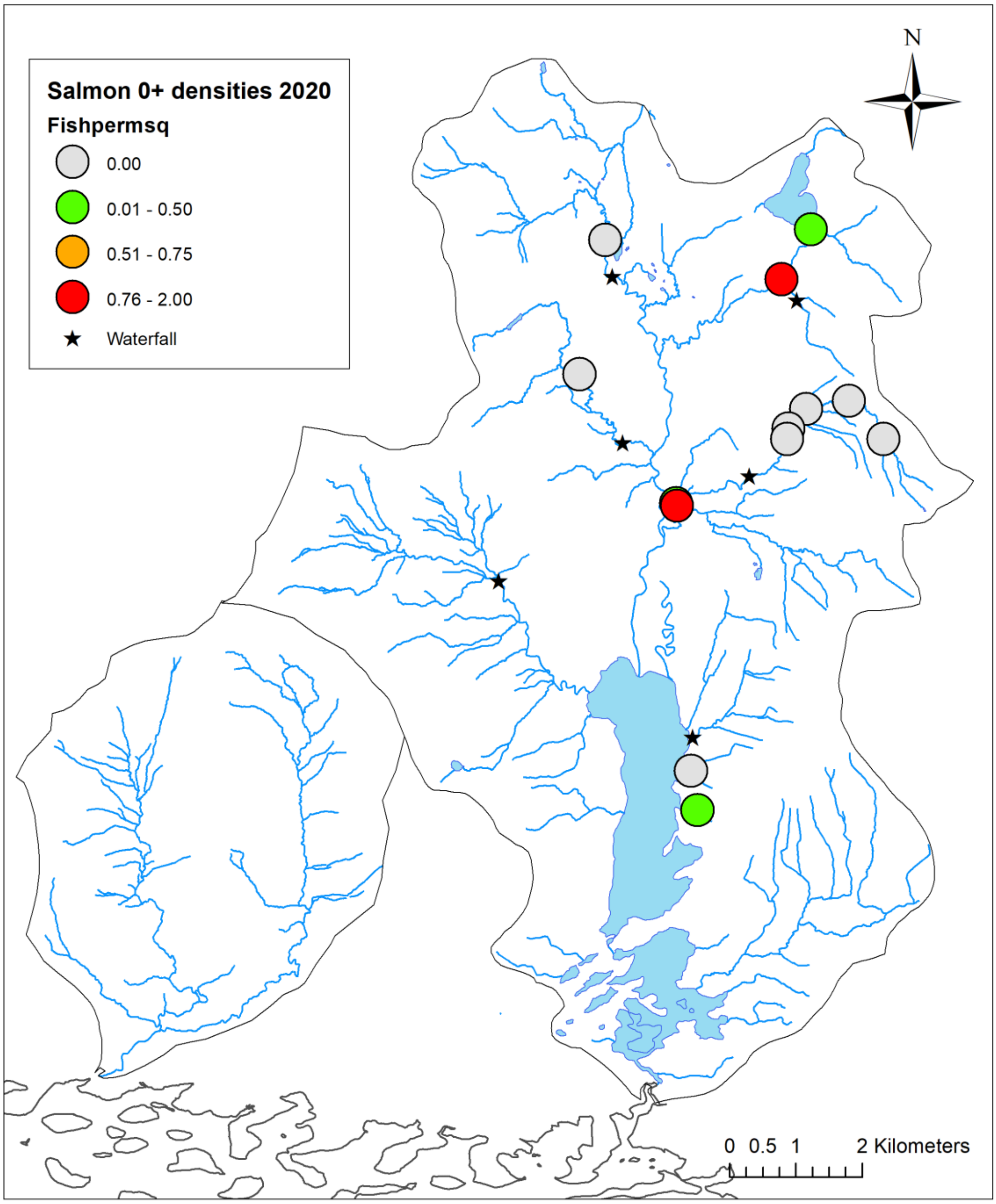

Figure 9-2: Densities of 0+ salmon calculated from the 2020 electrofishing survey of the Burrishoole catchment.

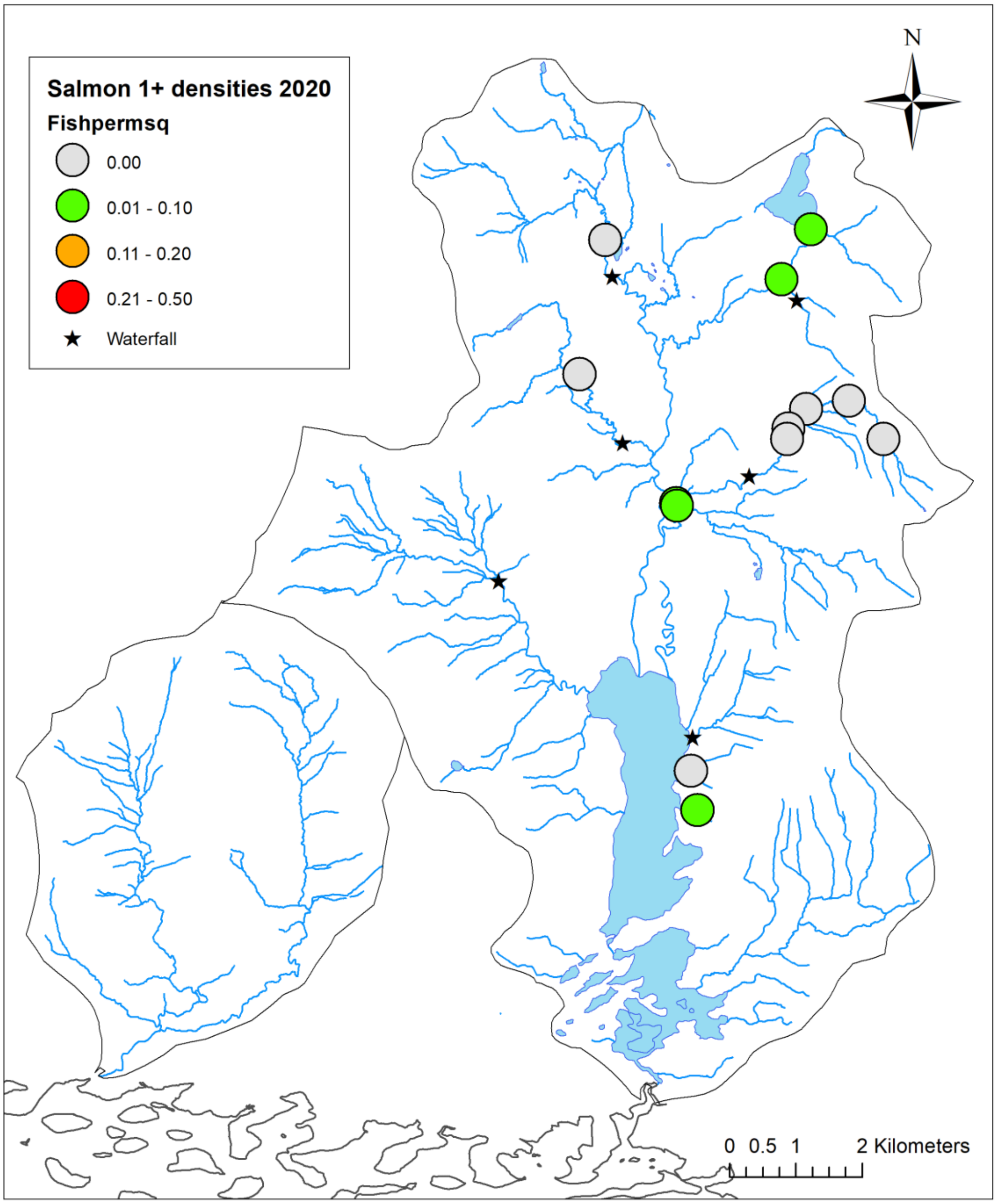

Figure 9-3: Densities of 1+ salmon calculated from the 2020 electrofishing survey of the Burrishoole catchment.

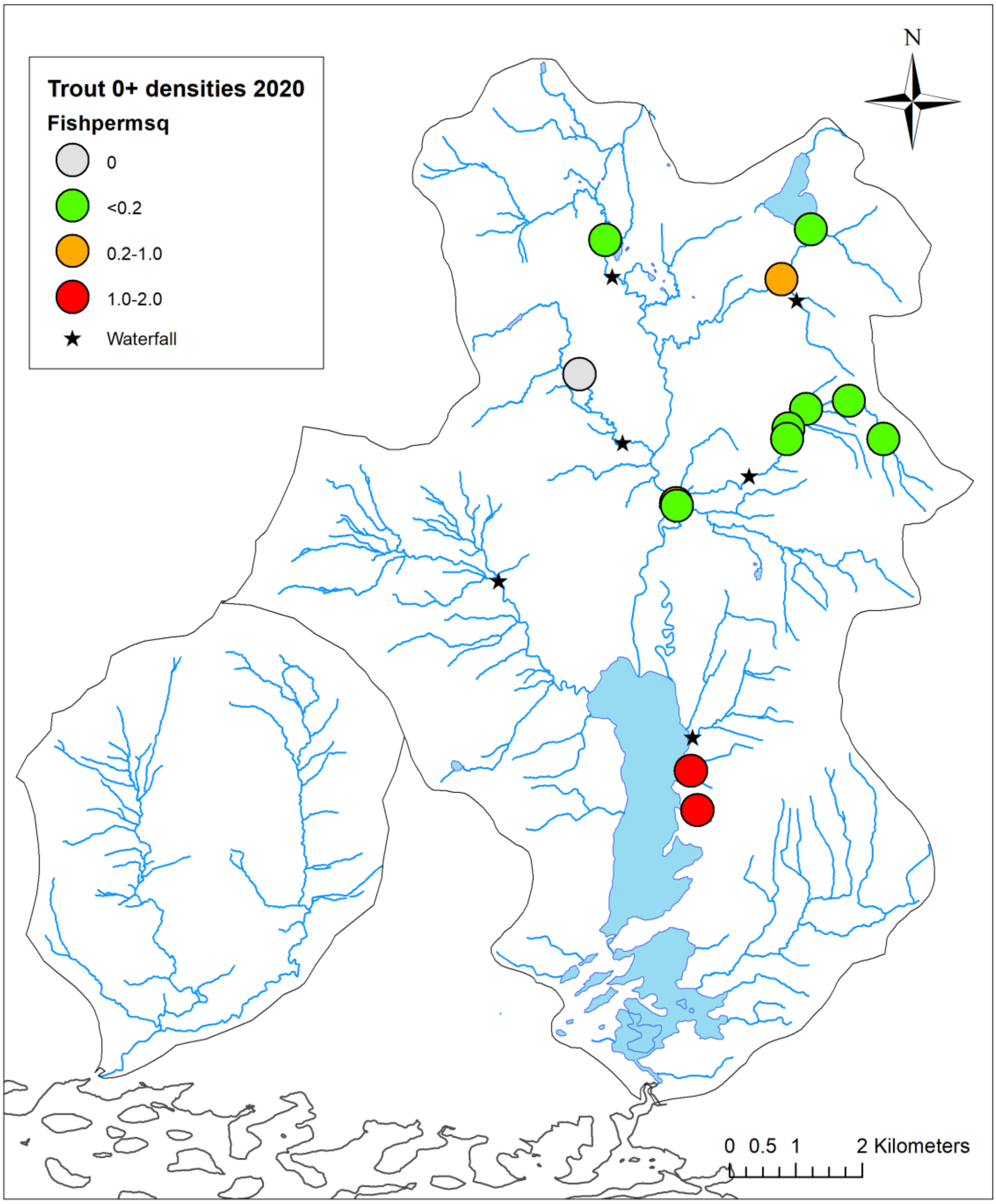

Figure 9-4: Densities of 0+ trout calculated from the 2020 electrofishing survey of the Burrishoole catchment.

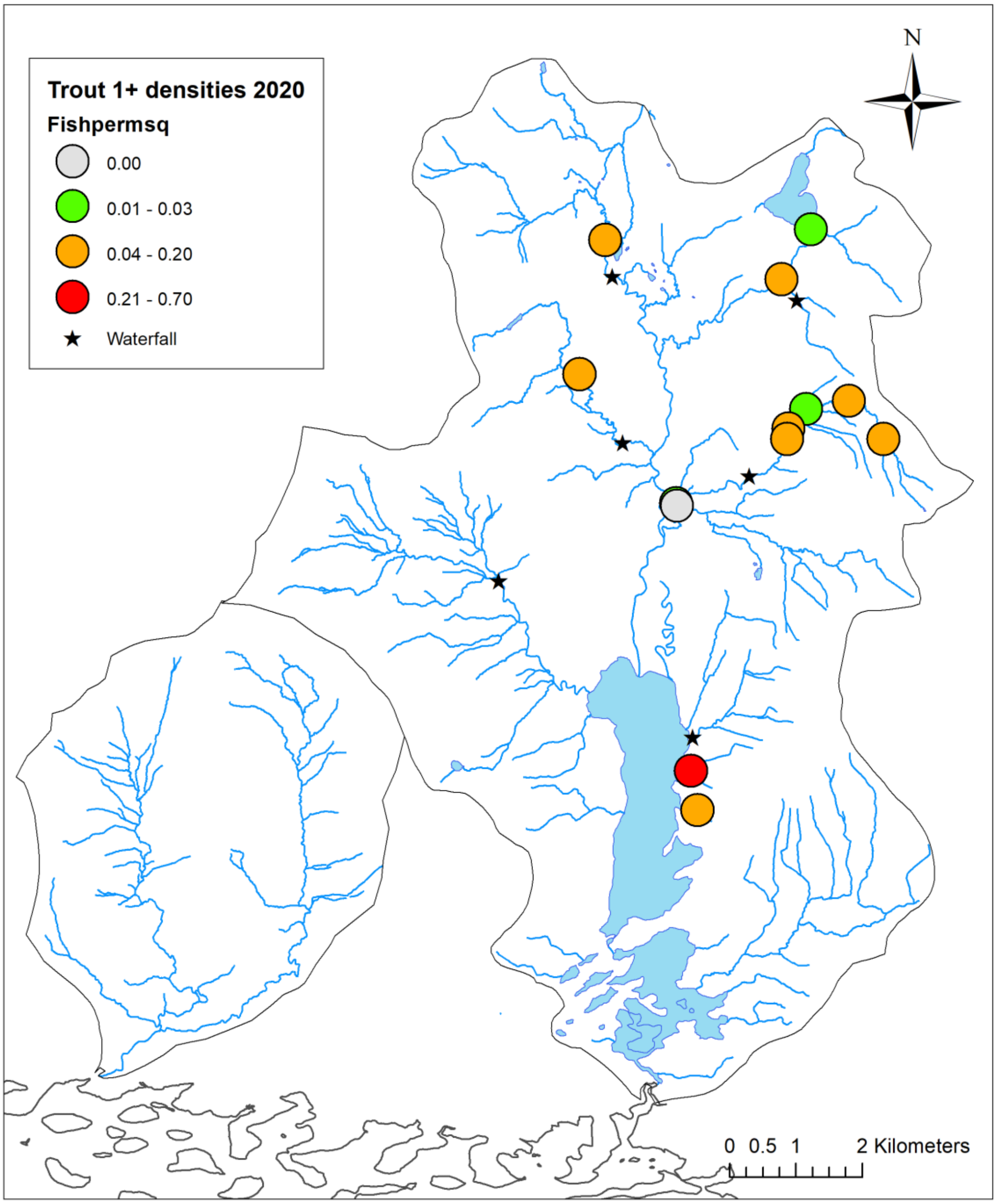

Figure 9-5: Densities of 1+ trout calculated from the 2020 electrofishing survey of the Burrishoole catchment.

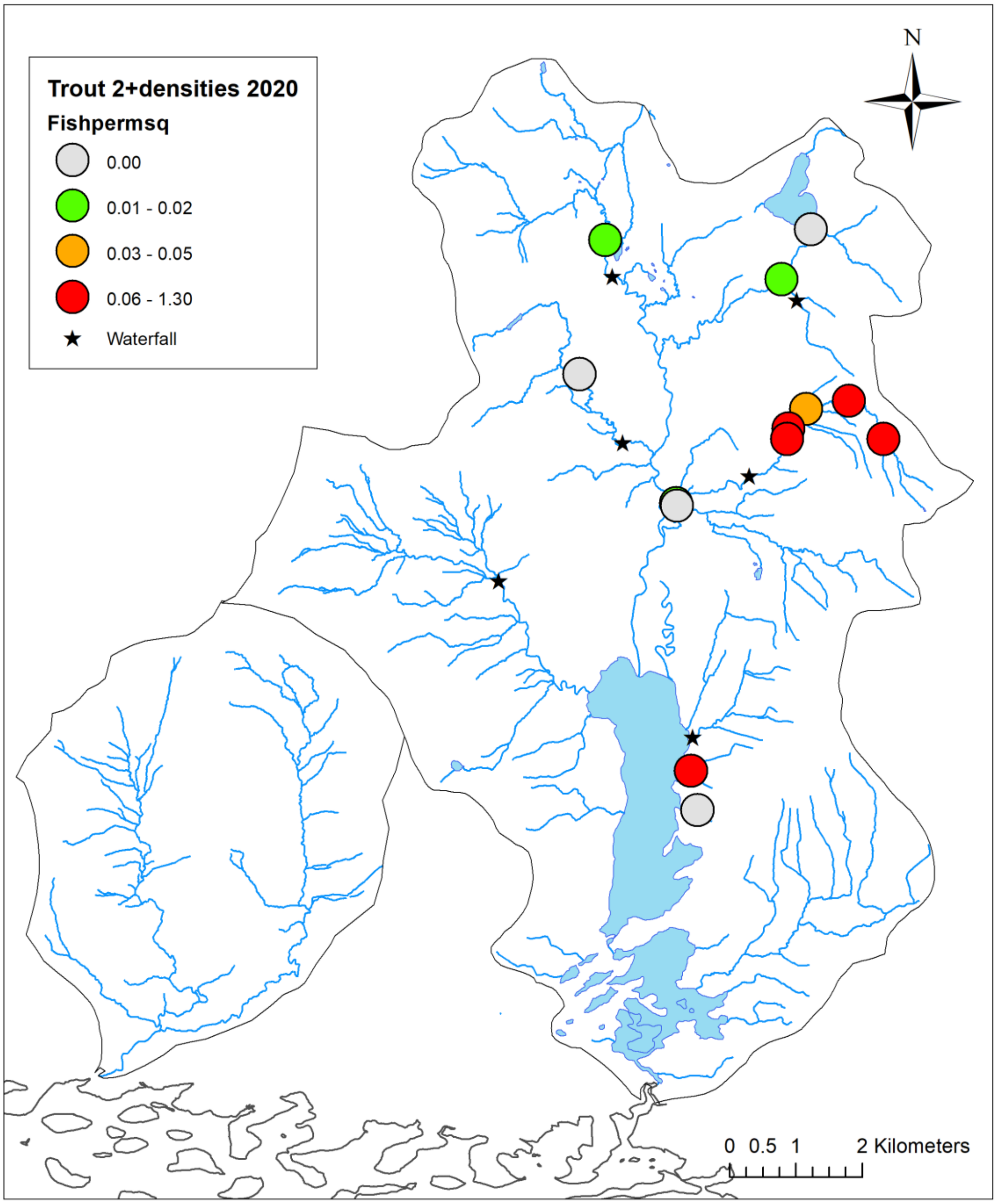

Figure 9-6: Densities of 2+ trout calculated from the 2020 electrofishing survey of the Burrishoole catchment.

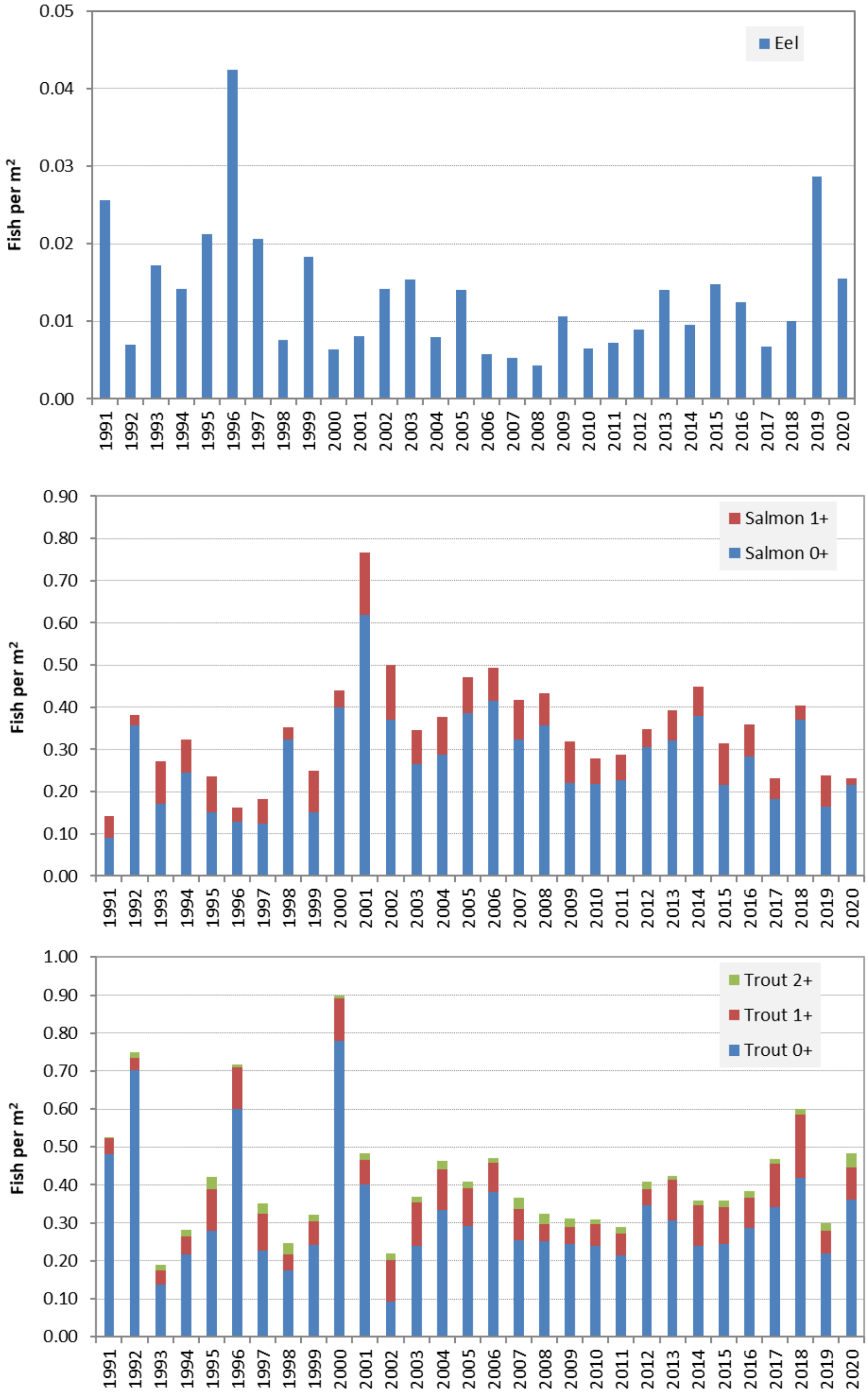

Figure 9-7: Average densities of eel, salmon and trout (fish per m²) calculated from electrofishing surveys of the Burrishoole and Owengarve catchments, 1991-2020. Note that the values for 0+salmon and trout do not include densities from the Rough river, sites 1-5 as these were stocked heavily for experimental purposes in some years.

10 Collaborative Research Programme

10.1 GLEON

In 2007, the Burrishoole catchment became a member of the Global Lake Ecological Observatory Network (GLEON: http://www.gleon.org), an association of limnologists, information technology experts and engineers whose goal is to establish a persistent network of lake ecology observatories (http://www.gleon.org). Work with GLEON working groups continued in 2020. The annual GLEON meeting was online, due to the COVID19 pandemic. Data from the Burrishoole catchment are being used in several GLEON working groups, including, the role of catchment processes and dynamics on lake metabolism and the role of lakes in the global carbon cycle. Elvira de Eyto served her fifth year on the steering committee. During 2020, we carried out field work for a GLEON project, GALACTIC, the aim of which is to assess microplastic occurrences in inland waters.

10.2 Cullen PhD Fellowships

In 2015, a call was put out for four PhD fellowships to be awarded for projects based in Burrishoole. Sean Kelly commenced his project in October 2015, and three others started in 2016.

The projects are as follows:

- Brian Doyle (E. Jennings, DKIT): Resolving the Organic Carbon Budget of a salmonid humic lake.
- Sean Kelly (M. White, NUIG) (COMPLETE): To investigate the dual influence of marine water and freshwater on the hydrography and related ecology of a coastal lagoon, Lough Furnace, Co. Mayo.
- Aisling Doogan (D. Brophy, GMIT): Investigation of the causes of early migration mortality in salmon and sea trout from the Burrishoole National Index River using acoustic telemetry in freshwater and coastal areas.
- Ross Finlay (T. Reed, UCC) (COMPLETE): Investigation of the early migration of salmon and brown trout from the Burrishoole National Index River using PIT tag technology in freshwater and brackish areas

By the end of 2020, Ross Finlay had successfully submitted and defended his thesis with a MSTeams viva due to COVID-19, while Brian, and Aisling are in the final stages on writing up.

10.3 PROGNOS

In 2016, we commenced the PROGNOS project, which was financed under the ERA-NET Cofund WaterWorks2014 Call. This ERA-NET was an integral part of the 2015 Joint Activities developed by the Water Challenges for a Changing World Joint Programme Initiative (Water JPI). Irish funding to the two partners (Marine institute and Dundalk IT) came from the EPA. In PROGNOS, the aim was to develop an integrated approach that links high frequency (HF) lake monitoring data to dynamic water quality models to forecast short-term changes in nuisance algal blooms and higher levels of dissolved organic carbon (DOC). This project finished in 2019, and in 2020, Tadhg Moore completed and defended his PhD thesis "Predicting in-lake responses to change using near real time models". Peer reviewed papers are in progress.

10.4 WATExR

In 2017, work began on the WATExR project, which is part of ERA4CS, an ERA-NET initiated by JPI Climate, and funded by MINECO (ES), FORMAS (SE), DLR (DE), EPA (IE), IFD (DK), RNC (NO) with co-funding by the European Union (Grant 690462). The project is running from 2017 to 2021. The aim of the project is to integrate state-of-the-art climate seasonal prediction and water quality simulation in a QGIS-based advanced solution to ensure efficient decision making and adaptation of water resources management to an increased frequency of climate extreme events. The project started in September 2017, with a kick-off meeting in ICRA Girona. The MIs role is to conduct the modelling work for the Burrishoole catchment, primarily focussing on using seasonal forecasts to predict fish phenology. Andrew French started as a post-doctoral researcher in February 2018 and made significant progress on collating and modelling fish phenology data from Burrishoole. More information can be found here: https://watexr.eu/

10.5 MANTEL

The Marine Institute is a partner in the MANTEL project which is a Marie Sklodowska-Curie Action. MSCAs provide funding for research-focussed organisations, such as universities, research centres and companies, to host foreign researchers and to create strategic partnerships with leading institutions world-wide. Innovative Training Networks (ITNs) are one area which are funded through MSCAs. In addition to organisations from different EU or associated countries, the participation of additional organisations from anywhere in the world, including from the non-academic sector, is encouraged. This is the role of the Marine Institute, as MANTEL is training a cohort of 12 PhD students, many of whom are using data collected in Burrishoole. MANTEL kicked off in 2017, and recruited throughout the year. Most of the students were in place by the end of 2017. In 2020, all students were collating data and writing their theses. Hares Khan came for a short secondment in March 2020, which was unfortunately cut short by the COVID-19 pandemic. Alex Hoke did a virtual secondment with us while she finished her paper about microbial responses to storms in Burrishoole. More information can be found here https://www.mantel-itn.org/.

10.6 Other catchment

During 2020, the catchment team continued collecting samples for inclusion in the GNIR (Global Network of Isotopes in Rivers - http://www-naweb.iaea.org/napc/ih/IHS_resources_gnir.html). GNIR is a global environmental observation programme dedicated to the compilation of isotopic assays of water, nutrients and particulate and dissolved constituents in global river systems. GNIR serves as an essential world-wide repository for riverine isotope data, and facilitates public dissemination of contributed riverine isotopic data through a cost-free user-friendly web portal. GNIR is a complimentary programme to the IAEA (International Atomic Energy Agency) well-established Global Network of Isotopes in Precipitation. Monthly samples are taken from the Black and Mill Race rivers, and dispatched to the IAEA facility in Vienna for analysis.

10.7 DkIT Landscape PhD students

Emma Drohan commenced a study of littoral carbon processing in September 2019 under the supervision of Prof. Eleanor Jennings and Dr Valerie McCarthy, and her first chapter will focus on a resurvey of littoral macroinvertebrates from Lough Feeagh. The project focus changed as a result of the COVID-19 pandemic, and is now focussed on macroinvertebrate variability at decadal, annual and sub-annual time scales. Sampling continued in 2020, and Emma is participating in the

Europonds project as an add-on to this PhD project https://freshwaterscience.ie/wp-content/uploads/2020/05/EuroPonds_Project.pdf . Ryan Smazal commenced his PhD in 2020 on the SEQUESTER project, supervised by Prof. Eleanor Jennings (DkIT) and Dr Catherine Dalton (Mary Immaculate College, University of Limerick). He is continuing the analysis of the Lough Feeagh Holocene core obtained during the Beyond2020 project.

10.8 BEYOND2020

BEYOND 2020 (Burrishoole Ecosystem Observatory Network 2020) is funded under the Marine Research Programme by the Irish Government. It is a multi-institute research cluster that is working with the Marine Institute Newport Catchment Facilities to build on the existing biological and sensor monitoring programme in the Burrishoole catchment in County Mayo by using next generation science and technology to inform ecosystem response to environmental change. The team, from six Irish and UK institutes, aim to maximise and enhance the current capabilities by undertaking new analysis on lake physics and aquatic ecosystem metabolism, modelling environmental variables in the recent past and into the near future, developing Burrishoole as a testbed for new chemical and biological sensors, undertaking new aerial observations using drone technology to inform on marine-freshwater links, and harnessing next generation 'omic science, to understand, predict and communicate the role and response of aquatic ecosystems in a changing global environment. In addition, the cluster will train a set of five postgraduate and four post-doctoral researchers in cutting-edge technologies, thus building capacity and ensuring the place of the Burrishoole Ecosystem Observatory Network at the forefront of national, regional and global network science in the coming decades. The project commenced in 2017 and work is ongoing. More information can be found here: https://www.dkit.ie/beyond-2020. The PIs are E. Jennings (DkIT) & P. McGinnity (UCC).

10.9 Unlocking the Archive

This project is a collaboration with the Marine Institute, funded under the Marine Research Programme by the Irish Government. An aim of the project is to consolidate national collections of scales, otoliths, associated images and data into a single biochronology repository, thus maximising the use of the archive by researchers. Time series of scale/otolith growth and chemical composition will be analysed within the project to investigate how migratory fish respond to environmental change. The PI on the project is Deirdre Brophy, GMIT.

10.10 Common garden experiments

Monitoring of the common garden experiments established in 2017, 2018 and 2019 in the Srahrevagh (Rough) river under the auspices of the SFI-DEL and BBSRC-SFI programmes was continued in 2020. These studies were set up to compare the relative performance of the progeny of wild and farm parents including their hybrid progeny in respect of survival, migration, growth, body morphology, microbiome development, metabolic potential, behaviour, energy management. In addition, an assessment of the performance of the experimental population of the progeny of resident and anadromous brown trout established as part of the ERC project in 2016 is also ongoing. These investigations are facilitated by daily monitoring of the river trap, seasonal electrofishing, deployment of extensive PIT tag antennae, respirometry, and supported by genetic based parentage assignment at UCC and Queen's University and gut microbiome community development enabled by genomic screening at the University of Glasgow. An integrated database of genetic and phenotypic data for some 25,000 individual observations has been established.

10.11 Pedigree construction

In 2020 as part of the SFI-DEL programme and the MI 'Core' monitoring programme, all returning adult salmon released into the upper catchment and post spawned kelts from the 2019 returning adult cohort were sampled for genetic enabled pedigree reconstruction. These fish now, in addition to complete genetic sampling of returning and potentially spawning adult since 2011 constitute a unique contemporary, multigenerational, whole river adult population pedigree. There are approximately 10,000 individuals included in the pedigree database with accompanying phenotypic data. Genetic profiling of the tissue samples collected is ongoing in UCC and QUB. These data, in addition to archive data already acquired to provide partial pedigree information for 1977, 1978, 1980, 1981, 1985 and 1989 (O'Sullivan *et al*. 2020) represent an outstanding resource for addressing fundamental questions in Atlantic salmon biology associated with for example effective population size, sexual selection, the quantitative genetic understanding of life history variation, reproductive contributions of mature male parr, straying, impact of cultured fish, climate variability and global warming. As part of the ERC project sampling for a pedigree based study of genetic and ecological determinants of anadromy was also progressed with respect to determining relative contributions of Burrishoole autumn and spring migrants (smolts) to sea trout returns.

O'Sullivan, R.J., Aykanat, T., Johnston, S.E., Rogan, G., Poole, W.R., Prodöhl, P.A., de Eyto, E., Primmer, C.R., McGinnity, P. & Reed, T.E. (2020). Captive-bred Atlantic salmon released into the wild have fewer offspring than wild-bred fish and decrease population productivity. *Proc. R. Soc. B*, 287: 2020167, 10.1098/rspb.2020.1671.

10.12 Laboratory studies

Two papers were published in 2020 by Dr Louise Archer (as part of her PhD research based on controlled laboratory experiments undertaken under the auspices of the ERC research programme, which focussed on the migratory tactics of the offspring from two wild populations, namely the Erriff and Burrishoole (Bunaveela) that naturally show life-history variation in migratory tactics (one anadromous, i.e. sea-migratory, one non-anadromous) when reared under variations of temperature and either optimal food or conditions food restriction) and how these responses might be mediated by inherent rates of metabolism. Smoltification rates were higher where food was restricted. Higher overall smolting rates in the naturally anadromous population suggested an inherited component to anadromy/migration decisions, but both populations showed variability in migratory tactics. Importantly, some fish from the naturally non-anadromous population became smolts in the experiment, implying the capacity for migration was lying "dormant," but they exhibited lower hypo-osmoregulatory function than smolts from the naturally anadromous population. Measures of standard metabolic rate, maximum metabolic rate and aerobic scope were all found to be higher in the anadromous population. The results suggest different components of metabolic rate can vary in their response to environmental conditions, and according to population-background and the sex of an individual.

Archer, L., Hutton, S., Harman, L., McCormick S., O'Grady, N, Kerry, J.P., Poole, W.R., Gargan, P., McGinnity, P., Reed, T. (2020). Food and temperature stressors have opposing effects in determining flexible migration decisions in brown trout (*Salmo trutta*). *Global Change Biology*, 26 (5), Volume26, 2878-2896.

Archer, L., Hutton, S.A., Harman, L., Poole, W.R., Gargan, P., McGinnity, P. & Reed, T.E. (2020). Metabolic traits in brown trout (*Salmo trutta*) vary in response to food restriction and intrinsic factors. *Conservation Physiology* Volume 8, 10.1093/conphys/coaa096.

A number of studies on gut microbiomes in Atlantic salmon led by the University of Glasgow as part of the BBSRC-SFI project and by APC (UCC) and Teagasc as part of an IRC funded research initiative were accepted for publication in 2020. As an element of her PhD Dr Sian Egerton (UCC) investigated how gut microbiome communities would respond to replacing fishmeal with plant protein and supplementing with fish protein hydrolysate she had sourced from blue whiting (Egerton et al. 2020). It was found that while plant protein significantly altered gut microbial composition, significantly decreasing diversity. It was also shown that farmed Atlantic salmon parr could grow successfully on an 80% plant protein diet when supplemented with a partly-hydrolysed FPH (PHP) obtained. Dr Raminta Kazlauskaite (UoG) developed as part of her PhD studies a three compartment in vitro simulator (a series of linked bioreactors) 'SalmoSim' of the Atlantic salmon GI tract and associated microbial communities. Real salmon and SalmoSim responded similarly to the introduction of novel feed, with majority of the microbial taxa (96% Salmon, 97% SalmoSim) unaffected. SalmoSim, has enormous potential as a prescreening tool for new feed ingredients and additives, as well as being used to study antimicrobial resistance and transfer and fundamental ecological processes that underpin microbiome dynamics and community composition. Dr Chloe Heys characterised the intestinal microbiota of Atlantic salmon sampled from farmed and wild (Rough River experiment) environments using genetic sequencing analysis. Across different gut compartments of the intestinal tract of farmed fish, there was no evidence of adaptation among gut microbes to their environment. In wild fish, declining taxonomic and functional microbial community richness was found as fish mature through different life cycle stages. The declining richness demonstrates an increasing role for the host in filtering microbial communities that is correlated with age. A limited subset of gut microflora adapted to the farmed and wild host environment among which Mycoplasma spp. are prominent.

Egerton, S., Wan, A., Murphy, K., F. Collins, F., Ahern, G., I. Sugrue, I., Busca, K., Egan, F., Muller, N., Whooley, J., McGinnity, P., Culloty, S., Ross, P. & Stanton, C. (2020). Replacing fishmeal with plant protein in Atlantic salmon (*Salmo salar*) diets by supplementation with fish protein hydrolysate. *Scientific Reports*, doi.org/10.1038/s41598-020-60325-7.

Kazlauskaite, R., Cheaib, B., Heys, C., Ijaz, U., Connelly, S., Sloan, W.T., Russell, J., Martinez-Rubio, L., Sweetman, J., Kitts A., McGinnity P., Lyons P. & Llewellyn, M. (2020). SalmoSim: the development of a three-compartment in vitro simulator of the Atlantic salmon GI tract and associated microbial communities. *Microbiome* 9, 179.

Heys, C., Cheaibb, B., Busettia, A., Kazlauskaite, R., Maiera, L., Sloan, W.T., Ijaz, U.Z., Kaufmannc, J., McGinnity, P. & Llewellyn, M.S. (2020). Neutral processes dominate microbial community assembly in Atlantic salmon, Salmo salar. *Appl Environ Microbiol.* 86:e02283-19.

10.13 Ecological studies – Sticklebacks

The Beyond 2020 study of ecological and genetic differentiation among stickleback populations occurring in Lough Furnace continued in 2020 as part of Floriane Leseur's PhD project. A previous PhD study of the same populations by Mark Ravinet (QUB) suggested the presence of three distinct ecomorphs differentiated on the basis of phenotypic and genetic characteristics (i.e., low, partial and completely-plated), with little genetic evidence for hybridisation among ecomorphs. In contrast, to the earlier study there appears now sufficient morphological evidence only to support the presence of two ecomorphs in the system (a low and a completely-plated ecomorph). The completely-plated ecomorph is morphologically similar to phenotypes found breeding in fully saline rock pools located along the neighbouring coastline. The low-plated stickleback found in Lough Furnace are morphologically similar to those types found in the freshwater parts of the Burrishoole system. In

Lough Furnace, the two ecotypes overlap both spatially and temporarily during the breeding season. Breeding experiments show successful interbreeding of ecomorphs is possible, at least between low-plated males and completely-plated females, yet genetic evidence suggest they do not hybridise. It would appear that mate choice is important in preventing gene flow between the ecotypes. Alternately and possibly in conjunction, disruptive selection operating of maladapted intermediate ecotypes could contribute. Both would represent valuable avenue for further investigation.

10.14 AMBER

A GIS Framework 'Atlantic salmon atlas' for deploying new models for calculating river widths from catchment feature data, river reach specific habitat area, river reach juvenile salmon production potential, river connectivity and for acquiring projections of future river reach specific water temperatures and discharge values likely to result from global warming is in development as part of the AMBER Project. The addition of river habitat area and juvenile salmon production potential measures to weight primary data greatly enhance current assessments of EPA WFD Ecological Quality Scores, river connectivity indices in respect of new trans-European in-river barrier data collected as part of the EU H2020 AMBER project (Belletti et al. 2020) and recently published future climate projections. A key deliverable of the project will be a visualisation tool similar to that provided by the EEA within the WISE water information system (www.WISE), where the WISE framework presents results as interactive tables, graphs, statistics and maps with overviews at the various levels of geographical organisation from river reach to sub-basin to basin and to super-basins. The framework when operational should provide a powerful toolkit with multiple applications, including environmental impact assessment, attribution of impacts, environmental risk analyses, public and scientific communication, landscape protection, regulation, spatial planning, environmental scheme assessment, climate adaptation, cost benefit analysis, a system for environmental and economic accounting of natural capital.

Belletti, B., Garcia de Leaniz, C., Jones, J., Bizzi, S., Börger, L., Segura, G., Castelletti, A., van de Bund, W., , Aarestrup, K., Barry, J., Belka, K., Berkhuysen, A., Birnie-Gauvin, K., Bussettini, M., Carolli, M., Consuegra, S., Dopico, E., Feierfeil, T., Fernández, S., Fernandez Garrido, P., Garcia-Vazquez, E., Garrido, S., Giannico, G., Gough, P., Jepsen, N., Jones, P.E., Kemp. P., Kerr, J., King, J., Łapińska, M., Lázaro, G., Lucas, 108. M.C., Marcello, L., Martin, P., McGinnity, P., O'Hanley, J., Olivo del Amo, R., Parasiewicz, P., Pusch, M., Rincon, G., Rodriguez, C., Royte, J., Till-Schneider, C., Tummers, J.S., Vallesi, S., Vowles, A., Verspoor, E., Wanningen, H., Wantzen, K.M., Wildman, L. & Zalewski, M. (2020). More than one million barriers fragment Europe's rivers. *Nature* 588, 436–441.

10.15 SALMSON - Super-sized smolt production

The SALMSON smolt project is funded by the European Maritime Fisheries Fund, administered by BIM through the Knowledge Gateway Scheme. The project aims to utilise the new state-of-the-art freshwater RAS (Recirculating Aquaculture System) at the Marine Institute's Newport research facility to produce large Atlantic salmon smolts and monitor their performance through smoltification and following transfer to sea. The project produced its first cohort of S0 and S1 Atlantic salmon smolts in 2020. The system was stocked with two strains of Atlantic salmon fry in May 2020 and after 11 months produced 5,500 smolt weighing an average of 310 g. This was compared to the conventional flow through system which produces salmon smolts weighting an average 100 g in the same period.

Analysis of growth post marine input, over a five-month period in 2021, projects that the production of Atlantic salmon smolts of 300 g has the potential to reduce the time spent at sea by four months when compared with conventional smolts produced in flow-through systems. This has the potential to reduce environmental impacts as well as increasing the productivity of the marine sites.

10.16 HYDRO-fish - Target neutraceutical technologies for a smarter and sustainable Irish aquaculture industry.

The Marine Institute is collaborating with NUI Galway, Bio-Marine Ingredients Ireland and Teagasc on the HYDRO-fish project funded through the Disruptive Technologies Innovation Fund run by the Department of Business, Enterprise and Innovation with administrative support from Enterprise Ireland. The project, which runs from 2019-2022 is investigating the use of fish protein hydrolysates (FPH) in the feed of Atlantic salmon. The FPH in this study is based on pelagic fish bycatch, where the waste by-products are processed into FPH which is incorporated into the salmon diet. A selection of such fish species is envisaged to guarantee fluidity of supply. The use of FPH can reduce the reliance on fish meal in addition to the numerous health and sustainable benefits associated with their use.

The Marine Institute has overall responsibility for field trials investigating the performance of fish fed FPH diets. Three feed trials (spring 2020, spring 2021 and autumn 2021) were planned at the Marine Institute Newport and Lehanagh Pool facilities. All fish sampling throughout the trials is carried out in collaboration with NUIG. The Marine Institute is also involved in the economic assessment of FPH. This work is ongoing and consists of life cycle assessment of FPH, a study of certification requirements and a consumer and market analysis. In conjunction with Údarás na Gaelteachta and the Blue Bio Ineval project, a joint questionnaire was developed and circulated in the summer of 2021. The results from this study will be compiled and analysed by the end of 2021.

10.17 SeaMonitor

SeaMonitor is a unique marine research project studying the seas around Ireland, Western Scotland and Northern Ireland. The project is led by the Loughs Agency and supported by another eight leading marine research institutions including the Marine Institute using innovative marine species tracking technology to better understand and protect vulnerable marine life in our oceans.

Funding for the SeaMonitor project has been provided by the EU's INTERREG VA Programme (Environment Theme), which is managed by the Special EU Programmes Body (SEUPB), to the tune of €4.6m. Match-funding for this project has been provided by the Department for Agriculture, Environment and Rural Affairs in Northern Ireland and the Department of Housing, Planning and Local Government in Ireland. This substantial investment will extend the existing network of 'smart' buoys and oceanographic models – delivered by sister projects COMPASS and MarPAMM – so that a line of acoustic receivers runs between the island of Ireland and Scotland.

11 Publications

11.1 Peer-review 2020

Archer, L., Hutton, S., Harman, L., McCormick S., O'Grady, N, Kerry, J.P., Poole, W.R., Gargan, P., McGinnity, P., Reed, T. (2020). Food and temperature stressors have opposing effects in determining flexible migration decisions in brown trout (*Salmo trutta*). *Global Change Biology*, 26 (5); 2878-2896; doi.org/10.1111/gcb.14990

Archer, L., Hutton, S.A., Harman, L., Poole, W.R., Gargan, P., McGinnity, P. & Reed, T.E. (2020). Metabolic traits in brown trout (Salmo trutta) vary in response to food restriction and intrinsic factors. *Conservation Physiology* Volume 8, 10.1093/conphys/coaa096.

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11.2 Reports – 2020

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ICES. 2020. NASCO Workshop for North Atlantic Salmon At-Sea Mortality (WKSalmon, outputs from 2019 meeting). ICES Scientific Reports. 2:69. 175 pp. http://doi.org/10.17895/ices.pub.5979

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Report of the 2020 ICCAT intersessional meeting of the Bluefin Tuna species group

https://www.iccat.int/Documents/Meetings/Docs/2020/REPORTS/2020_BFT_ENG.pdf

Report of the 2020 second ICCAT intersessional meeting of the Bluefin Tuna species group

https://www.iccat.int/Documents/Meetings/Docs/2020/REPORTS/2020_2_BFT_ENG.pdf

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Annex 1: Upgrade of Smolt Grids on Downstream Traps

Background

The Marine Institute's research facility, formerly the Salmon Research Agency of Ireland, established in the Burrishoole catchment in 1955 has undertaken a wide range of fisheries and environmental programmes. The Burrishoole system has international importance as an index site for salmonid and eel monitoring. Data collected from the fish trapping facilities are used nationally and by the International Council for the Exploration of the Seas (ICES) to assess the overall status of the Irish stocks on an annual basis. The system is utilised as one of the key index systems for salmon, sea trout and eel in the north Atlantic.

Fish Traps

The fish traps, situated at installations lying between Loughs Furnace and Feeagh, possess the unique advantage of being able to monitor all movements of fish to and from freshwater. The trapping facilities at the Mill Race, constructed in 1959, and the Salmon Leap, completed in 1969, consist of full upstream and downstream traps. The Mill Race and the Salmon Leap Downstream Trap were refurbished in 2012 and the gates and screens in the Salmon Leap Upstream Trap were replaced in 2013.

Both Salmon Leap (1969/’70) and Mill Race (1958) downstream traps were designed (by C.J. McGrath) on the Wolf trap principle of a sloping grid (1:10) to let water pass through and separate fish into a downstream trap chamber. The wooden grids were made up of 3” x 1” iroko teak, subsequently oak, and spaced 3/8” apart (~9mm apart). The wooden grids were replaced in the mid 1990s and again in about 2007. The original design is described in the 1969 Annual Report.

There was a tendency for the timber to wear over time, and to become clogged with moss and algal growth, making efficient cleaning difficult, and therefore managing high water flows was inefficient and caused damage and mortality to fish.

Imsa Trap, Norway.

A similar trap based on the design of the Salmon Leap Trap was installed in 1975 on the Imsa River near Stavanger in Norway. All descending fish are caught in a Wolf trap (apertures 10 mm, inclination 1 : 10) situated about 100 m from the river outlet in the sea.

Through a collaboration on silver eels (see Poole et al 2018, Sandlund et al. 2017) and facilitated by the Site Manager, Knut Bergesen, the MI were made aware that aluminium grids were a viable alternative to timber, with much more efficient screening of water, low fouling and, with regular cleaning, much kinder to the fish. A visit to Imsa took place in January 2020 during the design

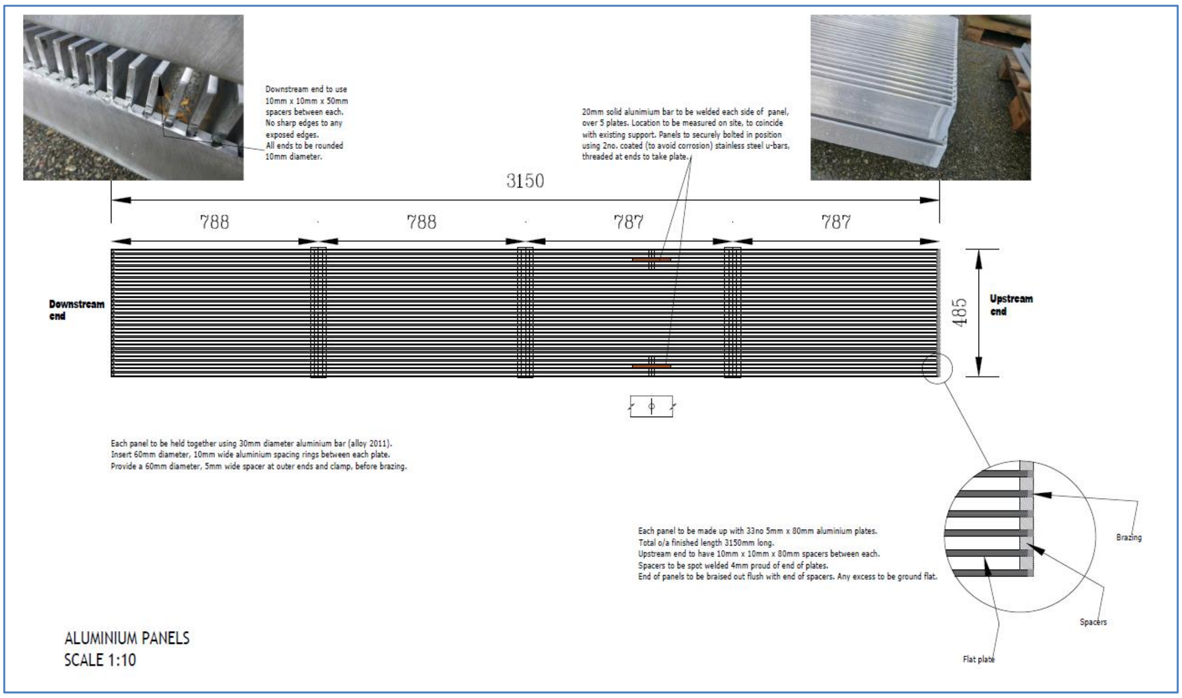
phase of the project to examine the grids, take dimensions and photographs and to assess the structure and accessories for cleaning the grids..

Design and Installation

The design of the new grids for the Salmon Leap was undertaken by Brendan McHugh, Jennings O'Donovan and Partners Ltd., Sligo and construction and installation was by Ballina Engineering Works, supported by Michael O'Malley Construction, Ballina.

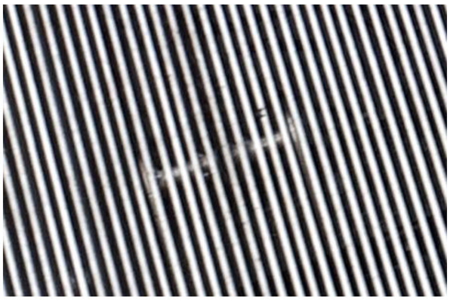
The final specification agreed on for the aluminium grids was 6082 T6 grade aluminium with dimensions of 76.2x4.76mm (see appendix 1). Construction commenced at the end of May 2020 on a sample panel, which was then modified to reduce the amount of welding and avoid heat warping.

Each panel was constructed to the following specification, modified slightly to take account of the 76.2mm x 4.76mm dimensions.



Installation of the panels on the SLDT took place between 22 July 2020 and 14th August 2020 and on the MRDT on the 29th December 2020. The aluminium grids were supported at the top end by the concrete cill and at the lower end and at two mid-way points by steel beams and recycled plastic shims cut to the required thickness and clamped to the steel girder with stainless steel clamps.

Each panel was held in place by two U-bolts tightened around the beam underneath.



And the junction between the panel and the concrete wall was covered with a triangular section of greenheart timber.

This is the final installation completed at the Salmon Leap Downstream Trap.

The Millrace downstream trap grid also replaced in 2020 in aluminium. This was installed in December 2020, following the same specification, but installing it as one single panel. The joint between the panel and the wall was constructed in stainless steel triangular section.

Original timber grid in the MRDT

New Aluminium Grid MRDT

Accessories

A cleaning fork, designed by the Imsa team in Norway, was also manufactured in aluminium.

Appendix 1; Technical Specification Sheet for the Aluminium Alloy

Aluminium Alloy 6082

Aluminium alloy 6082 is a medium strength alloy with excellent corrosion resistance. It has the highest strength of the 6000 series alloys. Alloy 6082 is known as a structural alloy. In plate form, 6082 is the alloy most commonly used for machining. As a relatively new alloy, the higher strength of 6082 has seen it replace 6061 in many applications. The addition of a large amount of manganese controls the grain structure which in turn results in a stronger alloy.

It is difficult to produce thin walled, complicated extrusion shapes in alloy 6082. The extruded surface finish is not as smooth as other similar strength alloys in the 6000 series.

In the T6 and T651 temper, alloy 6082 machines well and produces tight coils of swarf when chip breakers are used.

Applications

6082 is typically used in:

- High stress applications
- Trusses
- Bridges
- Cranes
- Transport applications
- Ore skips
- Beer barrels
- Milk churns

Chemical Composition

Element	% Present
Si	0.7 to 1.3%
Fe	0.5%
Cu	0.1%
Mn	0.4 to 1.0%
Mg	0.6 to 1.2%
Zn	0.2%
Ti	0.1%
Cr	0.25%
Al	Balance

Mechanical Properties

Temper	O	T4	T6/T651
Proof Stress 0.2% (MPa)	60	170	310
Tensile Strength (MPa)	130	260	340
Shear Strength (MPa)	85	170	210
Elongation A5 (%)	27	19	11
Hardness Vickers (HV)	35	75	100

Physical Properties

Property	Value
Density	2.70 g/cm^3
Melting Point	555°C
Modulus of Elasticity	70 GPa
Electrical Resistivity	0.038x10^{-6} Ω.m
Thermal Conductivity	180 W/m.K
Thermal Expansion	24x10^{-6} /K

Alloy Designations

Aluminium alloy 6082 also corresponds to the following standard designations and specifications:

AA6082	HE30
DIN 3.2315	EN AW-6082
ISO: Al Si1MgMn	A96082

Welding

6082 has very good weldability but strength is lowered in the weld zone. When welded to itself, alloy 4043 wire is recommended. If welding 6082 to 7005, then the wire used should be alloy 5356.

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Temper

The most common tempers for 6082 aluminium are:

- O – annealed wrought alloy
- T4 – Solution heat treated and naturally aged
- T6 – Solution heat treated and artificially aged
- T651 - Solution heat treated, stress relieved by stretching and then artificially aged

Fabrication

Process	Rating
Workability - Cold	Good
Machinability	Good
Weldability – Gas	Good
Weldability – Arc	Good
Weldability – Resistance	Good
Brazability	Good
Solderability	Good

Supplied Forms

6082 aluminium is available from Aalco in the following forms with a T6 temper:

- Square bar
- Square box section
- Rectangular box section
- Channel
- Tee section
- Equal angle
- Unequal angle
- Flat bar
- Tube
- Sheet

Plate and shate can also be supplied as 6082-T651.